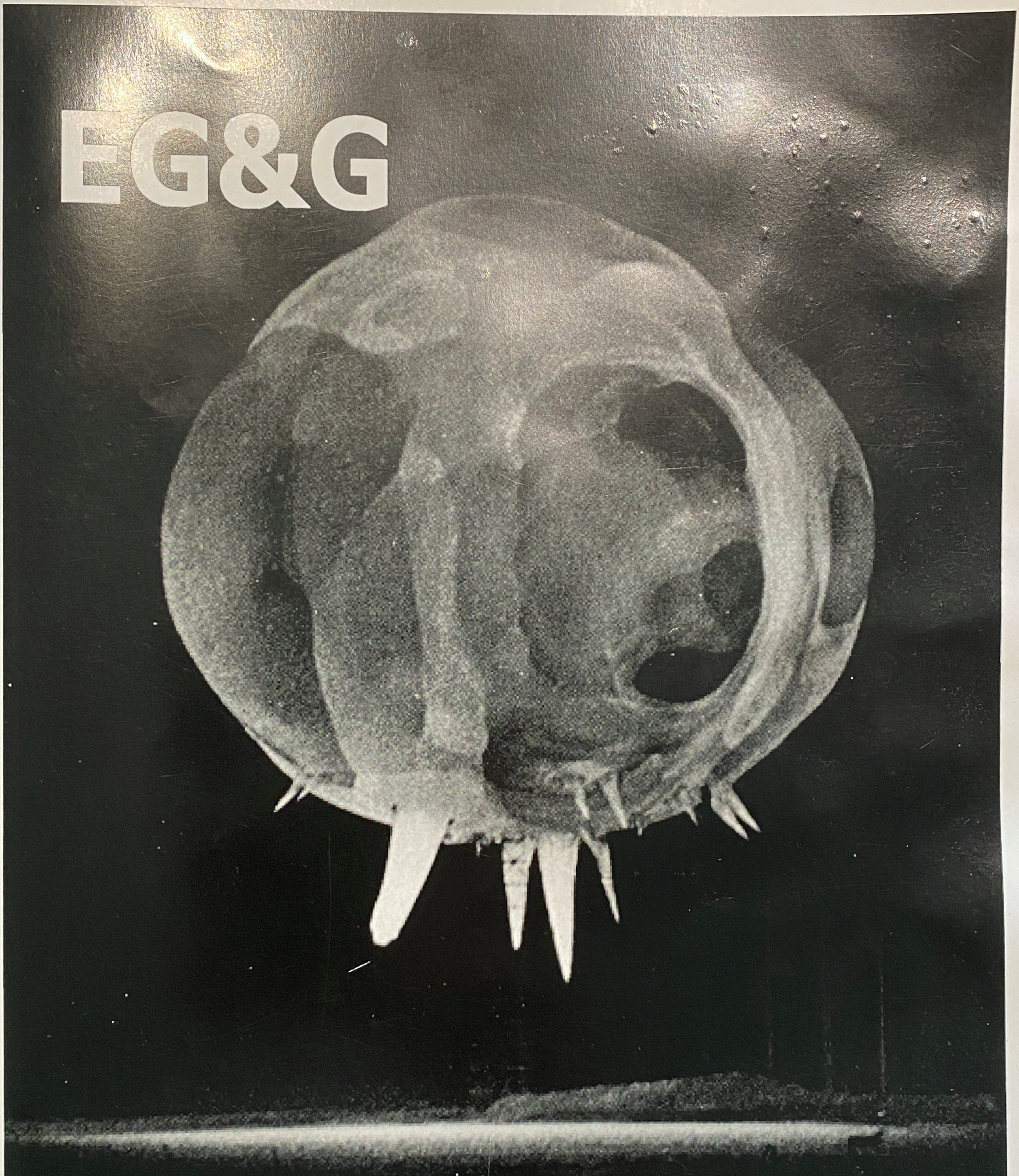
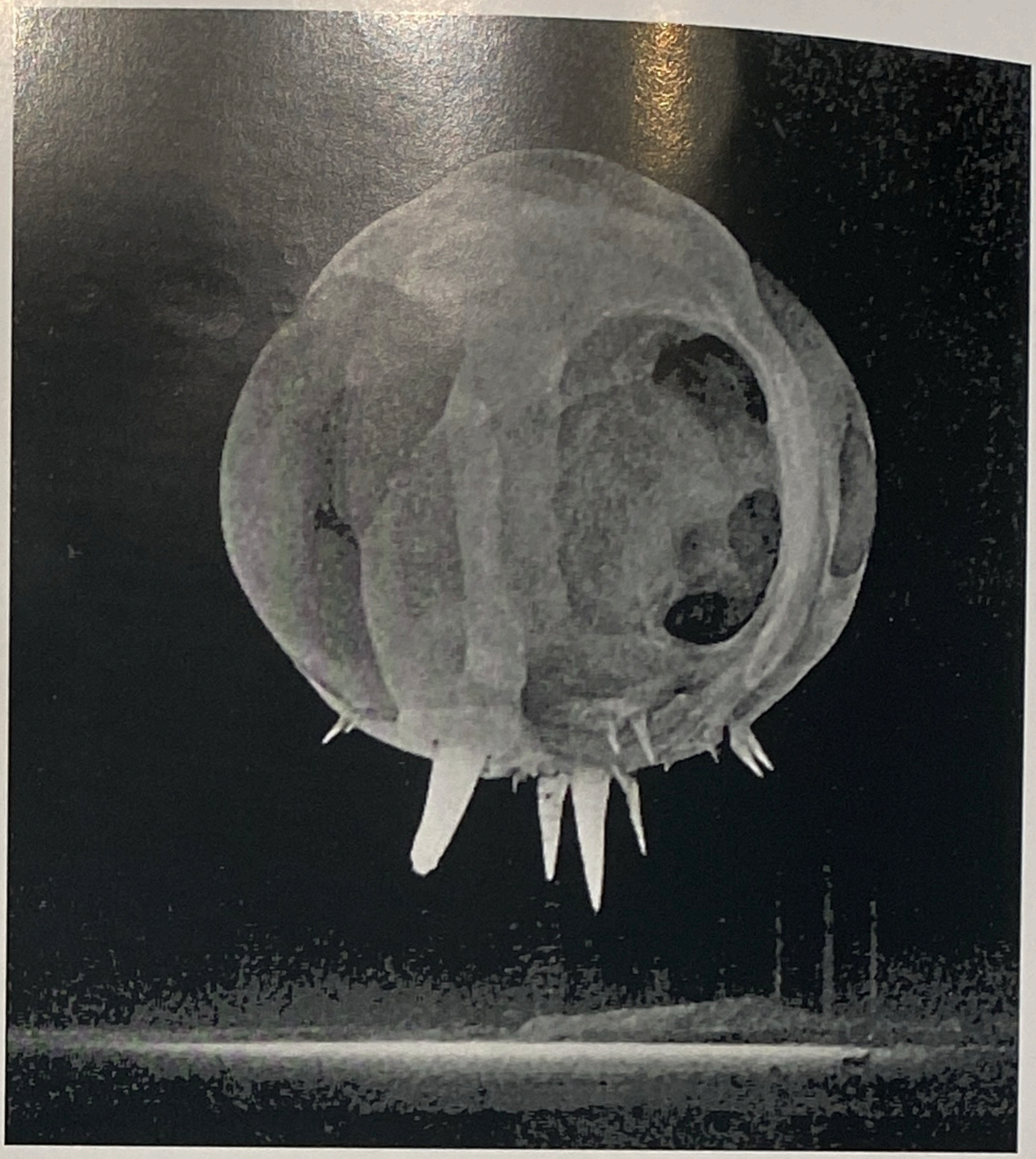
EG&G



Historic Involvement in the Nuclear Weapons Program



The cover picture is a photograph taken with an EG&G RAPATRONIC camera of a nuclear detonation within the first few microseconds. The test was a tower shot during Operation Greenhouse on Enewetak.

Photos included in this document courtesy of National Nuclear Security Administration and EG&G, Inc. archives.

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EG&G ENERGY MEASUREMENTS GROUP

Peter Zavattaro pictured with the Founders during an Annual Meeting of the Corporation in the 1980s

A brief history of EG&G, Inc.

Preface

The story about EG&G, Inc. is compiled from a variety of sources, principally EG&G newsletters and articles dating back to 1956. Two books provided a lot of specific information about the earliest years: a book by Barney O'Keefe, ***The Nuclear Hostages,*** written in 1983, and An ***Account of the Return to Testing by the United States after the Test Moratorium*** (unclassified version) by William Ogle, published in 1986. There are also my own recollections and contributions of many of my colleagues from EG&G, the Department of Energy, and the National Weapons Laboratories. For brevity, I've limited the story mainly to the Weapons Test Program and other Nevada programs, with excursions into EG&G Corporate for continuity. The early years of the company's history are inextricable from the histories of the laboratories and the AEC, and there are stories from every event and field trip. A few are included in this brief history.

Peter Zavattaro

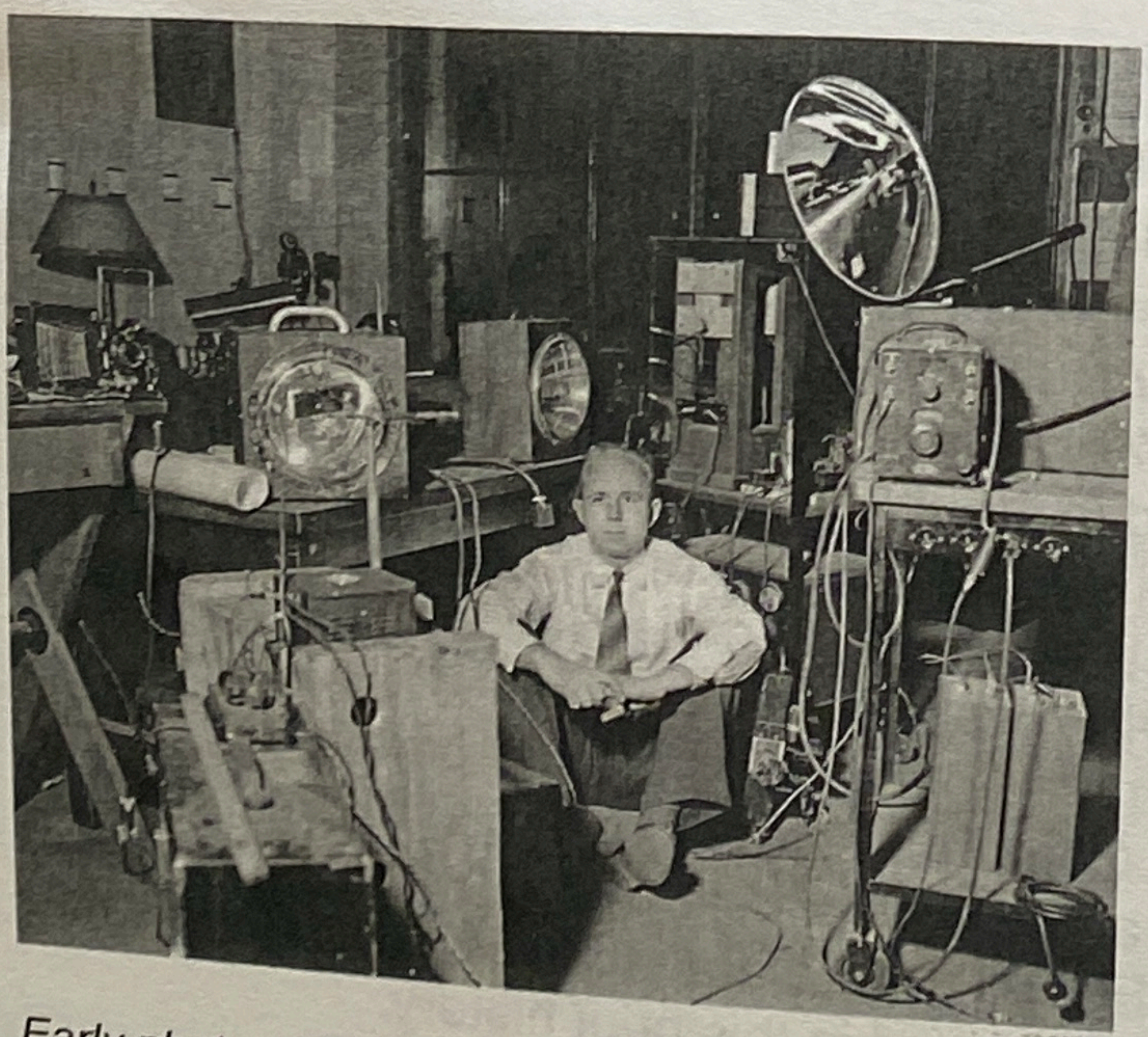
The Beginning

Dr. Harold Edgerton, a young Massachusetts Institute of Technology (MIT) Instructor, was interested in developing stop motion techniques to study rotating machinery. He first made "time stand still" while still a graduate student in 1927. Stop motion was achieved using a mercury arc rectifier that produced a short flash of light synchronized with the speed of the motor under study. In 1931, he partnered with Kenneth J. Germeshausen, one of his graduate students. Through their collaboration, the xenon flash tube, invented by Germeshausen, was further developed for use in stroboscopic applications. The xenon flash tube was much brighter and easier to use, resulting in the ideal vehicle to pursue Edgerton's interest. Three years later, Herbert E. Grier, also one of Edgerton's graduate students, joined the partnership to organize the experimental systems related to the strobe work. The partnership did extensive research in strobe flash photography and worked to develop electronic flash or strobe into products. The three never had a written agreement, nor was there any specific point at which the partnership was formed. They simply pooled their resources and worked together on whatever consulting task or measurement problem that came along.

One of their first designs to become a product was the Strobotac, licensed to General Radio Company. The Strobotac was a small, portable strobe unit with an adjustable pulse rate. By shining the Strobotac on a rotating object and matching the pulse rate to the speed, stop motion was achieved. In 1940, they produced the first portable flash unit for news photographers, a product that was marketed through Eastman Kodak.

During the war, Doc Edgerton concentrated on electronic stroboscopic techniques that could be used for night aerial photography as an alternative to flares. The partnership built, demonstrated, and sold airborne systems to the Military. The systems were flown for many important missions in Europe and the Pacific during the war, they were used and contributed to the success of the Normandy invasion.

The war effort completely and permanently changed the direction of the partnership. Besides Edgerton's activity, Germeshausen joined the MIT Radiation Laboratory and became deeply involved in hydrogen thyratrons and modulators for radar transmitters. Grier worked with the Draper Laboratory in the Instrumentation Lab, which eventually became the connection to the Manhattan Project.



Early photo of Edgerton in his MIT lab among some of his flash systems.

An early photo of the founders, from left to right, Grier, Edgerton, and Germeshausen.

Bernard (Barney) J. O'Keefe, though not a member of the original partnership, was the fourth person who significantly affected the course of the company. Barney O'Keefe was an ensign in the U.S. Naval Reserve. With an engineering background and interest in radar, he hoped to be attached to the Naval Research Laboratory in the Washington, D. C., area. Instead, he was given new orders, sending him to Santa Fe, New Mexico, as part of Engineering "Project Y." Barney O'Keefe thus became involved with the Manhattan Project in its early phases. He worked on firing systems and later participated in the deployment of the nuclear weapons from Tinian Island that were dropped on Hiroshima and Nagasaki. After the war, he was with one of the first engineering teams to go into Japan and continued with a long career in nuclear weapons testing.

Wartime picture of O'Keefe, located in the front row, just right of center.

Although O'Keefe's original assignment was to work on the arming radars located in the tail of the nuclear weapon, he became interested in the technical problems of the design of the detonator firing unit for the implosion device. To pursue this interest, he managed to get transferred to the firing group, X-5, in the Explosives Division at Los Alamos. Since the time was so short for the design and production of the firing sets at Los Alamos, the procurement people set out to find an existing factory they could commandeer. They found an ex-Raytheon factory in Boston, Massachusetts, that was assembling night aerial photography systems for the EG&G partnership under Herb Grier's supervision. The experience of Grier's group with large electrical capacitor banks used in the airborne flash systems was just what was needed for producing the electrical detonating system of the nuclear implosion weapon. It looked like the right match, and action was taken to bring them on board.

The production of the stroboscopic flash units was stopped, and the factory was converted to the manufacture of bomb firing sets. Also at this time, Lou Fussell, Los Alamos X-5 Group Leader, decided, through his contacts at Harvard, that the partnership was the logical group to work on the new triggering mechanisms.

There was no time to clear factory workers or set up proper security; as a result, the workers and their supervisors were told that the product was an advanced version of equipment for night aerial photography, and the factory was operated as an uncleared facility. The area soon had Army counter-intelligence people infiltrating into the factory and surrounding stores and restaurants. Here was an ostensibly wide-open facility, just outside Kenmore Square, developing and assembling what was now a key critical component for the atomic bomb program. Herb Grier's contribution during that time was the actual design and construction of the firing set for the Fat Man weapon. The first full scale test of the system was carried out at Tinian Island in the Marianas the day before it was used at Nagasaki.

While on leave, O'Keefe received orders to report to MIT for temporary duty to assist Herb Grier. When the Manhattan Project commandeered the Boston factory, they hired Grier as a consultant and cleared the partnership for the project. At the time all this occurred, the three partners were still associated with MIT, using the Institute's procurement and contracting infrastructure for their venture. O'Keefe went to MIT for what he thought would be a few weeks to help Grier organize a new research group. Instead, he remained there, except for regular travel to Los Alamos, until his discharge from the Navy in 1946. On his discharge from the service, O'Keefe was offered an appointment as a research associate in the MIT Electrical Engineering Department and as associate project manager for Grier's research project. He also continued private consulting activities at Los Alamos.

The first test of the nuclear device, Trinity, occurred on July 16, 1945, in Alamogordo, New Mexico. The first use of a nuclear weapon occurred on August 5, 1945, dropped on Hiroshima. Then on August 9, 1945, the second bomb exploded over Nagasaki.

O'Keefe was stationed on Tinian Island for the preparation and deployment of the bombs. In his book, "Nuclear Hostages", O'Keefe describes an incident with the Fat Man Weapon where he discovered and repaired a wiring problem just hours prior to deployment to Nagasaki.

In August 1945, there was an exodus of scientists from Los Alamos who felt their job was done and were anxious to return to academic life. Oppenheimer also formally resigned in August and rejoined the faculty at the Berkley campus at Cal Tech. With the Manhattan Project over and the infrastructure and temporary housing in major disrepair, the new Director, Norris Bradbury, had the job to rebuild staff and the site to a permanent Laboratory and town with a new mission in nuclear weapons development.

During the summer of 1946, Operation Crossroads, the first tests after the war, were carried out on the Bikini Atoll in the Marshall Islands, some 2,700 miles southwest of the Hawaiian Islands. The two tests were conducted more or less as effects tests to see how naval vessels would survive an atomic attack. Only these events and the events that were part of the Argus series were the only nuclear tests conducted without EG&G support.

On January 1, 1947, the Los Alamos laboratory, known as Project Y during the war, officially became the Los Alamos Scientific Laboratory (LASL).

In the summer of 1947, Director Norris Bradbury visited the partnership at MIT. He asked them to build a special firing set for a series of full-scale nuclear weapons tests planned to take place the following year in the South Pacific. He also asked them to deliver a network of timing signals for the experimenters participating in the tests and to actuate the unmanned instrumentation coordinated with the firing signal. The timing task quickly became a big one, requiring many thousands of dollars of submarine cable and instrumentation. Accepting this task led to an explosion in contract funding that overloaded the MIT procurement system. Also at this time, MIT was ready to resume teaching and non-military research, and balked at the proposed expansion. Grier suggested that he and his partners form a corporation to take over the government business and move it off campus. Thus, the corporation of Edgerton, Germeshausen and Grier, Inc. was formed in November 1947, a little over a year after the formation of the Atomic Energy Commission (AEC).

The first formal contract, a classified document, covered the period from November 12, 1947, to June 30, 1952. The estimated cost was $992,000 and included a fixed fee payment of $1,400 per month. This contract was updated with a new contractual instrument issued July 1, 1951, effective to June 30, 1955. Over the years the contract was amended and updated to handle the ever-increasing complexities of contract requirements and was renewed without competition until December 31, 1995.

As 1947 progressed and the project grew, the company moved to an old, converted auto parking garage on Brookline Avenue in Boston. While preparing for the upcoming Pacific operation, they were also tasked to develop a fast neutron measurement based on their expertise in fast pulse measurements. This pulled Edgerton into the project.

The organization of EG&G started to take form. Since Grier was project director of the nuclear testing work, he became president and chief executive officer of the new corporation. Edgerton, who wanted no business responsibilities, became the chairman of the board. Germeshausen took over responsibility for the roles of vice president and treasurer.

It was during Operation Sandstone in 1948 that the group became involved with the primary job of timing and firing. The test site for Sandstone was Enewetak, an atoll 200 miles to the west of Bikini. Doc Edgerton recollected on his arrival at Enewetak that he was greeted by O'Keefe, wearing only a pair of shorts. The place had tremendously high morale. Everybody there was working hard, accomplishing a lot, and enjoying every minute.

The Early Years of the Testing Program

The Sandstone series of three tests could be considered the start of the postwar nuclear weapons development program. The devices were detonated on towers to allow for accurate placement and alignment of cameras and detectors. EG&G equipment was used to remotely turn on instrumentation after the test area had been evacuated and, for instrumentation with short operating times, to start them in the final second between the arming and the firing of the device.

Striving for maximum reliability, a railroad signal-switching relay, the DN11, known for its proven durability and reliability, became the standard for timing and firing switching functions for many years. Timing and Firing was the task for Grier and O'Keefe. The real value of the DN-11 relay was the goodwill and reputation with the scientific community that accrued to the company for its unfailing performance.

Edgerton headed a small group responsible for the development of a system to measure the multiplication rate of neutrons, more commonly known as neutron reaction history or "Alpha." Grier and O'Keefe had responsibility to perform "dry runs," to check out equipment installations after the islands had been evacuated, to serve on the arming party with the test director, and to operate the equipment that armed and fired the devices. During Sandstone, Germeshausen stayed home to "mind the store."

By the end of Operation Sandstone, in May 1948, the company grew from six employees to twenty-six. Germeshausen and O'Keefe began to plan for commercial business to diversify beyond the nuclear weapons business. Grier was primarily interested in the government weapons testing business and concentrated his efforts there. At the end of their first year of corporate existence, EG&G had sales of slightly over a half million dollars and earned the princely sum of six thousand dollars in fee.

Herb Grier at the T&F console, giving the countdown. With only a few exceptions throughout the history of nuclear testing, EG&G was the "voice" for the countdowns.

Also, by the end of Operation Sandstone, Los Alamos's Z Division in Albuquerque had evolved from an earlier makeshift branch of Los Alamos into a self-contained entity. Z Division's responsibilities were the production, engineering, and procurement of all bomb components and materials required for the National Stockpile. Originally referred to as the "Sandia Base" due to its location near the Sandia mountains, it was later named Sandia Laboratories. In December 1948, the University of California asked the AEC to release them from Sandia Management. In July 1949, the AEC announced that it would negotiate a contract with Western Electric Company, the AT&T manufacturing subsidiary. A four-year contract to operate Sandia Laboratories on a cost basis without fee was signed on October 4, 1949.

On September 23, 1949, President Truman announced that the Russians had detonated their first nuclear weapon. The Russian test completely changed the nature of the debate on whether or not to pursue the development of the H-bomb, a burning issue at the time. On January 31, 1950, the President announced that the thermonuclear feasibility program would be pursued, disregarding the advice of the General Advisory Committee, a five-member civilian board headed by Robert Oppenheimer. The committee was set up to assist the AEC on technical and scientific issues. In June 1950, the Korean War broke out. A country willing to go to war to save South Korea was in no mood to stop the development of the hydrogen bomb.

At the time, Oppenheimer was an outspoken advocate for international control of nuclear weapons and was generally opposed to the hydrogen bomb. These positions garnered him powerful political enemies. One in particular, AEC Chairman Lewis Strauss, leveraged the Red Scare at the time to organize a hearing of the AEC Personnel Security Board in December 1953, and managed to revoke Oppenheimer's security clearance. This action effectively removed him from the nuclear political debate.

This decision to develop the hydrogen bomb changed the direction of activities at the company. Director Norris Bradbury put Los Alamos on a six-day workweek; all the contractors followed suit. The company's plan to balance out the government work with commercial activities had to be scrapped, at least for the time being while they grappled with the plans for the upcoming test program, now advanced to the early months of 1951. Because of the shortage of people and housing at Los Alamos, more work was contracted out. In addition to the company's timing and firing work, they were asked to do technical photography on the upcoming tests, primarily fireball photography that provided yield information. The extra photo work doubled the size of the company to 50 people.

While the preparations were underway for the upcoming Pacific tests, the Department of Defense (DoD) and the AEC together asked President Truman for authority to establish a continental test site that would not have the logistic and security problems of the Pacific atolls. Interest in a continental test site dates back to the summer of 1948, based on the reasoning of easier management, lower cost, and concerns over potential military action in the Pacific.

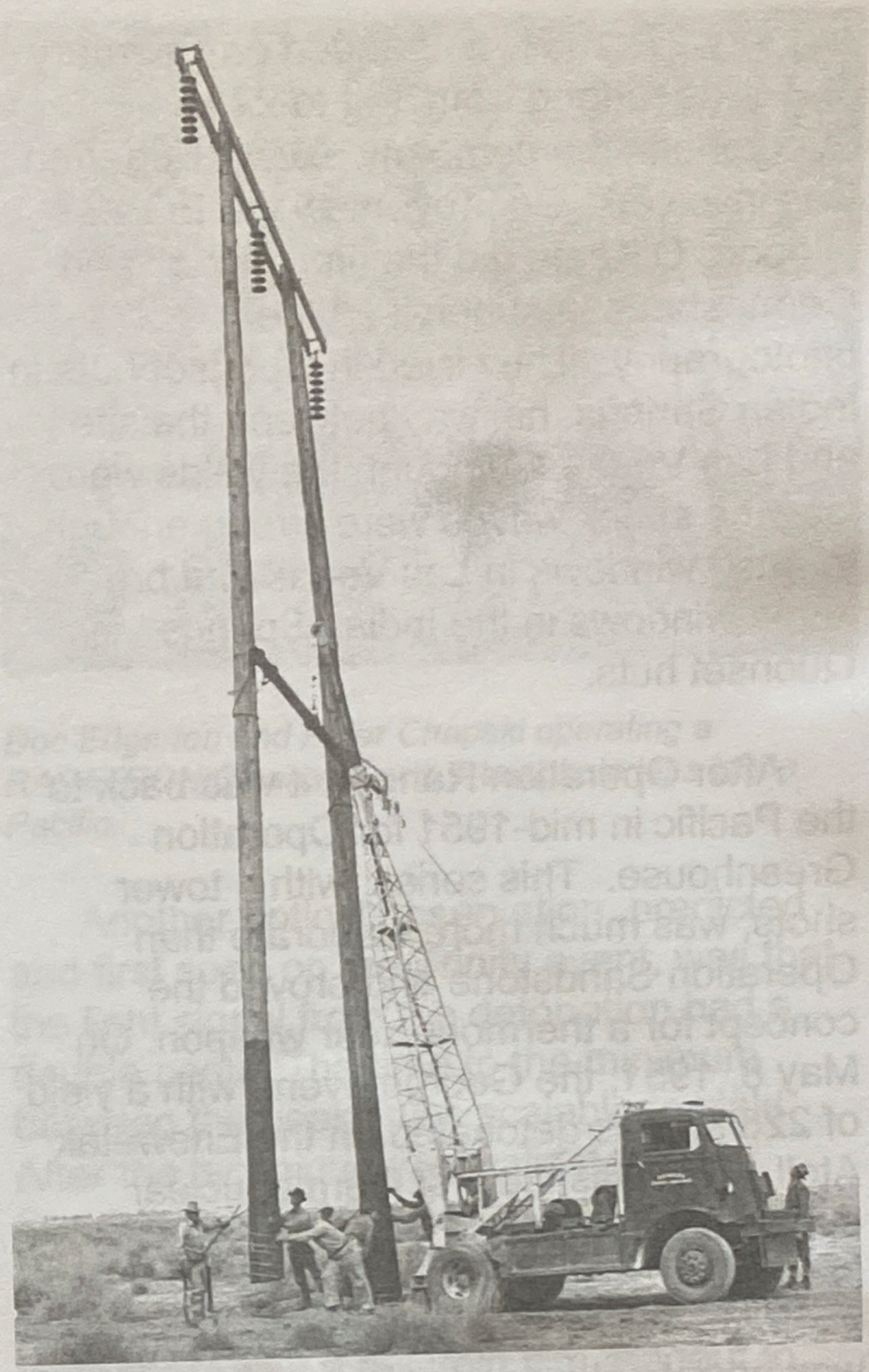
A study, Project Nutmeg, completed in 1949, analyzed possible continental locations in the West and even on the East Coast. The study proposed no specific site but favored the arid Southwest. A task force organized under the command of Lieutenant General Elwood (Pete) Quesada was directed to pick a site. In September 1950 a crash program was authorized to carry out the first continental tests before Operation Greenhouse in the Pacific. There were some design concerns that needed to be answered before the more costly Pacific tests were conducted.

General Quesada, an Air Force pilot, had flown many times from Nellis Air Force Base in North Las Vegas, Nevada, to the Las Vegas gunnery range. His familiarity with the desolate range north of Las Vegas may have been an influencing factor in choosing that site. On December 18, 1950, President Truman approved the choice. The site, a section of the gunnery range, 652 square miles in area, was turned over to the AEC to become the Nevada Proving Grounds. In the ensuing years this continental testing area more than doubled in size to approximately 1375 square miles and was renamed the Nevada Test Site (NTS).

As soon as the program, Operation Ranger, was approved, Quesada and Al Graves of Los Alamos flew to Boston to visit with the company to describe the program. Al Graves was J Division Leader, the laboratory division responsible for field tests. There would be five shots, with yields ranging from one to twenty-two kilotons, air-dropped over a dry lake at the new test site, with no firing requirement. They asked Grier and O'Keefe to coordinate the timing signals and do just enough high-speed photography to determine yield. For photographic stations, the company bought secondhand trucks, installed the cameras, checked them out in their converted garage, and had them driven to Nevada.

Grier and O'Keefe flew to Los Angeles, bought two Land Rovers, and drove across the desert to the site. After seeing Frenchman Flat, with nothing but dirt roads leading into it from the mountains, they were reluctant to string underground timing cables for fear of having them severed. They asked to have a set of telephone lines strung overhead, spanning the nine miles from the control room to an Alpha station at ground zero, and some seven miles to the photographic stations. Only for the last two miles to ground zero were the cables buried underground.

Reynolds Electric and Engineering Company (REECo), based in El Paso, Texas, was hired to do the job. The firm was put together by R. J. McKee, General Contractor, Inc, and Reynolds Electric. R. J. McKee was already well known to the AEC for its construction work at Los Alamos. This first task introduced REECo to a key role in the future activities of the NTS.



REECo crew assembling cable towers for the Ranger series.

The control room used for the first tests was in a portable wood frame building shipped from and provided by Los Alamos. The structure was set up in the vicinity of the present control point, CP-1.

Original control point building, showing the side away from the events, braced to sustain the shock wave.

This first continental test series went smoothly. Five airdrops commenced on

January 27, 1951, and ended on February 5. Yields ranged from 1 kt to 22 kt. Everyone in the company except Edgerton was involved. Grier oversaw the EG&G support, O'Keefe did the timing work and Germeshausen supervised the photography. They lived in Quonset huts in Indian Springs, halfway between the site and Las Vegas. Although the yields were low, the shock waves were strong enough to rattle windows in Las Vegas and break some windows in the Indian Springs Quonset huts.

After Operation Ranger, it was back to the Pacific in mid-1951 for Operation Greenhouse. This series, with 4 tower shots, was much more elaborate than Operation Sandstone and proved the concept for a thermonuclear weapon. On May 8, 1951, the George event, with a yield of 225 kt, was detonated on the Enewetak Atoll. This was the first thermonuclear explosion on earth.

In the fall of 1951 through mid 1952, it was back to Nevada for fifteen tests.

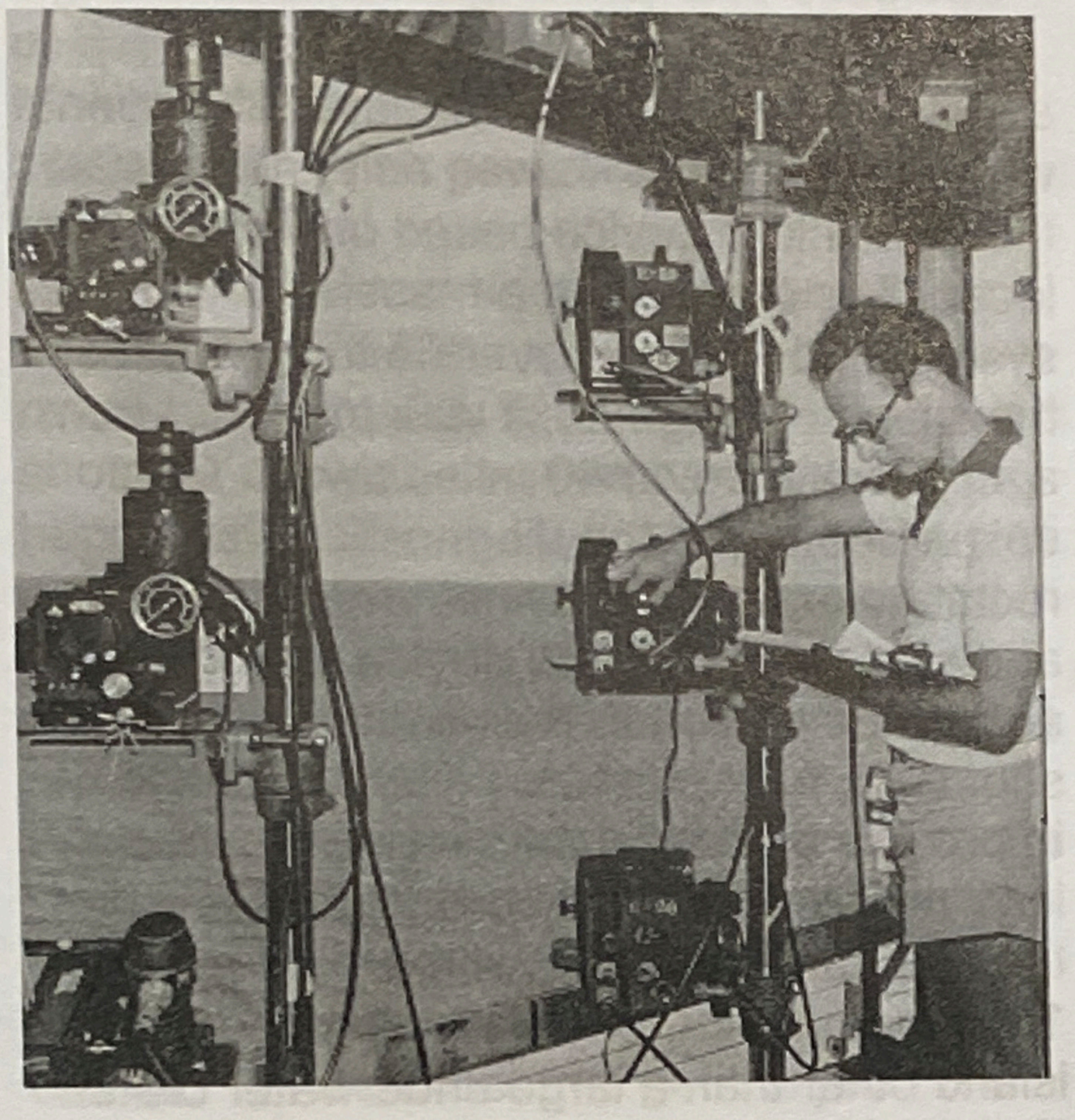
During those early days of testing, Bill Ogle, a Los Alamos section leader, formed a loosely knit technical group called POGO to deal with issues that arose as people worked through the learning process. A side point was that his secretary, Dorothy Whitcomb, who coined the name, later became Mrs. Herbert Grier, and retained a close association with the Nevada testing community for many years. Some people guessed the acronym stood for "People Out Guessing Ogle".

Also in 1951, the company opened a permanent office in Las Vegas and built a staff there to relieve some of the pressure for travel on the Boston-based people. During the first ten years or so, downtown Las Vegas addresses included South A Street, Wall Street, Highland Avenue, Western Avenue, and a few offices located on the grounds of the El Rancho Vegas resort, across from the Sahara Hotel. Finding new space was a continuing problem.

The development of the thermonuclear weapon became a contentious issue at Los Alamos. Edward Teller argued that management wasn't on board with the development of the "super", (as he called it), and the development was moving much too slowly. As a result, Teller left the laboratory and returned to the University of Chicago. In the fall of 1951, he began campaigning for a second weapons laboratory that would provide competition to LASL and pursue more strongly his ideas for thermonuclear weapon design. Through collaboration with Ernest Lawrence of the Lawrence Berkeley Laboratory (LBL), the concept began to materialize. They visited a square-mile site near Livermore, California, that became the selected location. During World War II, the site served as an inland Navy base to train pilots. After the war, the site was idled and was acquired by Lawrence as a possible location for a Materials Testing Accelerator.

Working through the difficulties of setting up and staffing a new weapons laboratory, the University of California Radiation Laboratory (UCRL) at Livermore, sister lab to LBL, started operations in the fall of 1952. Lawrence appointed Herb York as the first director of the newly formed weapons laboratory. In the late 1950s, York was called to Washington to fill a newly created post and Teller took over directorship shortly before the moratorium. In 1958, following the death of E. O. Lawrence, UCRL was renamed Lawrence Radiation Laboratory (LRL) in his honor.

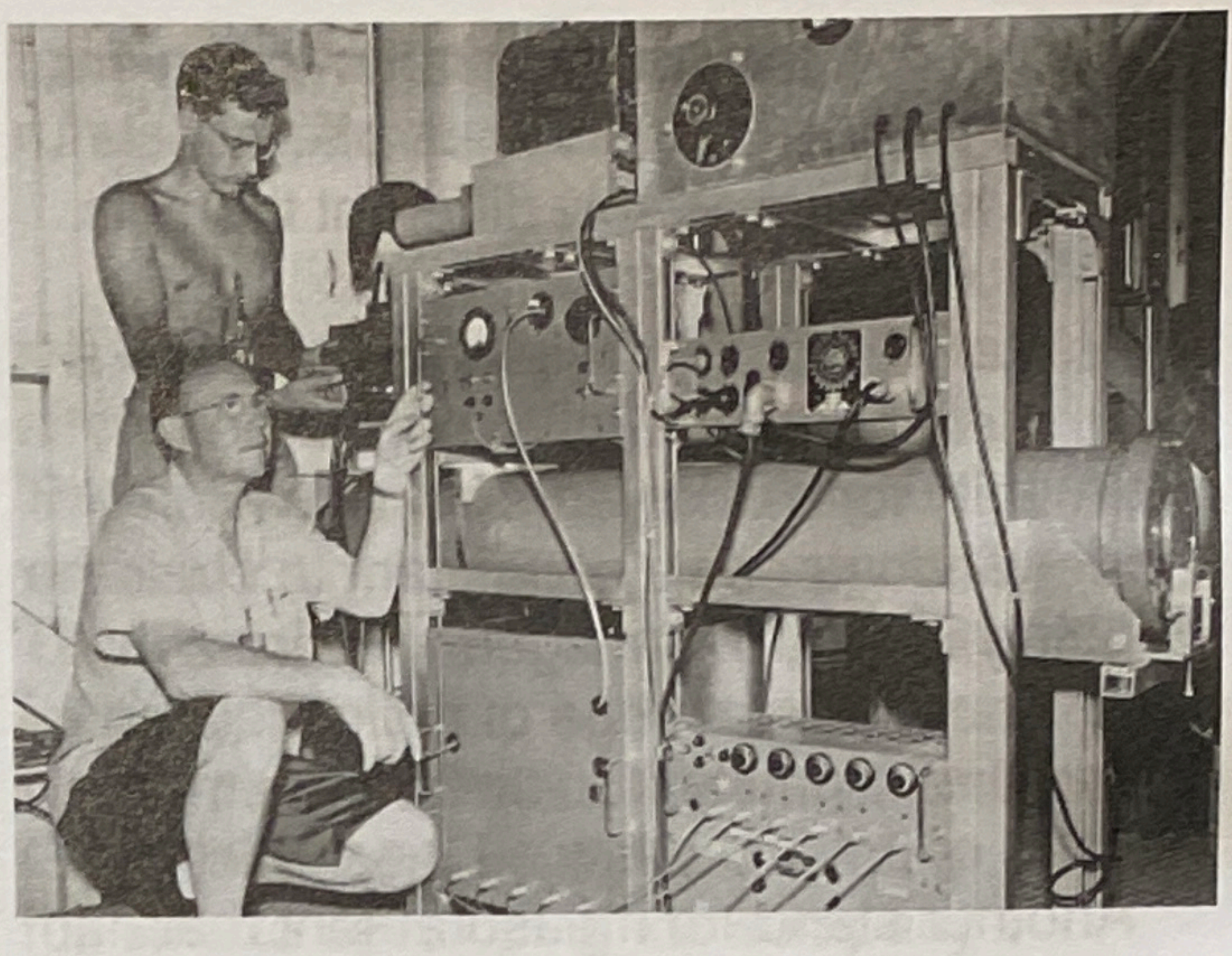
The key performance measure for a nuclear test is yield and it is desirable to have several independent measurements taken to assure the accuracy of the yield number. One method used is radiochemistry, where nuclear debris is collected in a variety of ways and assayed to determine yield. This method has always been under the purview of the two weapons laboratories. A second method that is traditionally used for all atmospheric tests is hydrodynamic yield, where the growth rate of the fireball is photographically recorded with high-speed framing cameras. The images are measured, frame by frame, to determine the growth rate of the fireball. This method was usually under the purview of EG&G.



Larry Mahoney running though the checklist for a bank of high-speed cameras on a Pacific test.

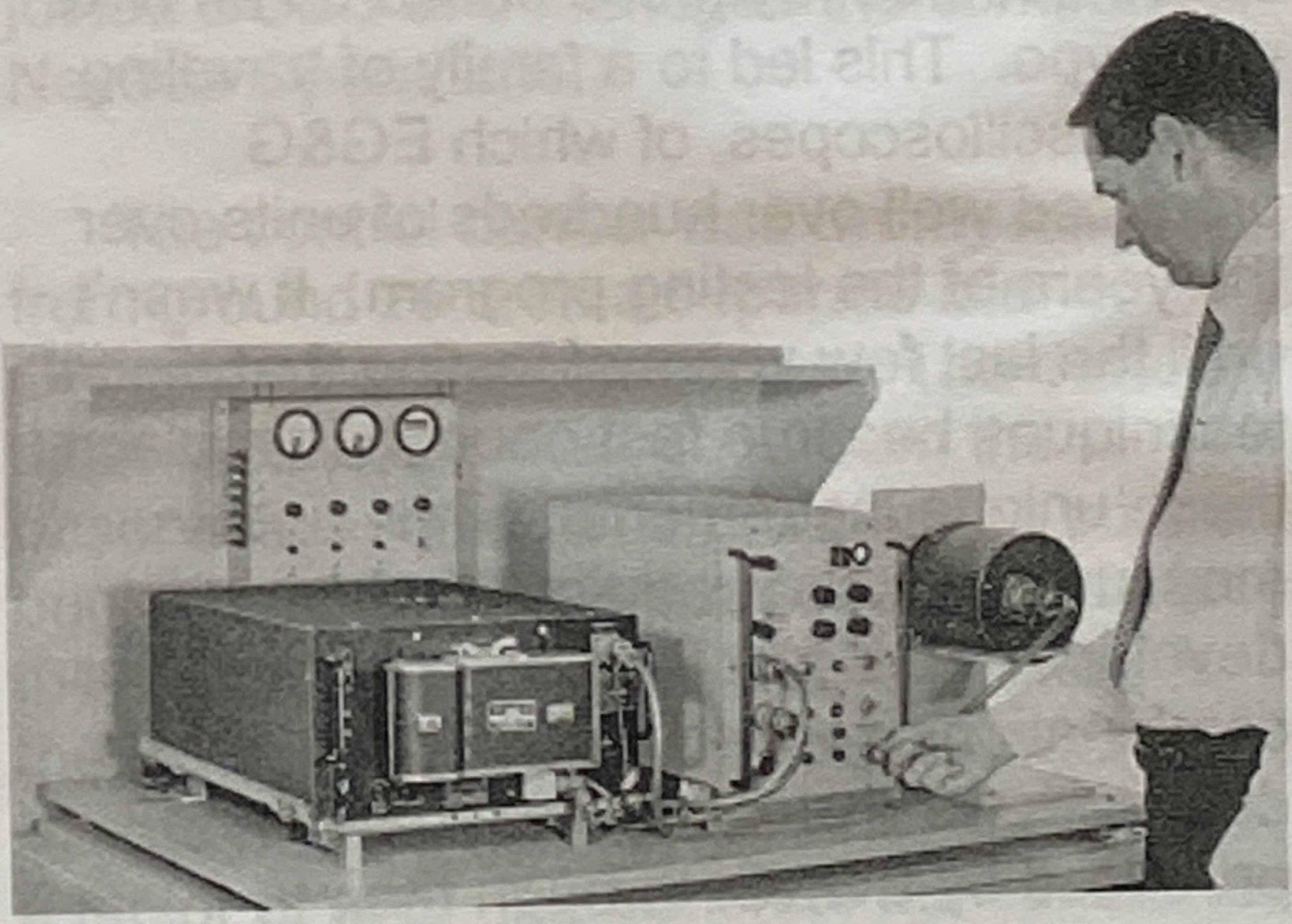
One of the earliest pieces of specialized diagnostic equipment developed for yield measurement was the RAPATRONIC camera, the name being an acronym for RAPid Action elecTRONIC shutter. The camera had a shutter that worked on the Faraday Effect, and was invented by Edgerton and Charlie Wyckoff, an EG&G scientist. The shutter consists of a Kerr Cell located between a pair of cross-polarizing filters. The Kerr Cell is electrically pulsed, rotating the plane of polarization of light with the magnetic field, thus opening the optical path for the duration of the pulse. Exposure times of less than one millionth of a second could be achieved.

The camera was first used in Enewetak for Operation Greenhouse and produced a number of extraordinary pictures of nuclear explosions. The camera produced only a single exposure, so banks of 4 to 10 cameras were synchronized to produce a time sequence of exposures.



Doc Edgerton and Peter Chapski operating a RAPATRONIC camera with a telephoto lens in the Pacific.

Another optical observation, predicted and first seen on the Trinity event, was that the light signal from the detonation had a double peak. The time to the minimum between the peaks was scalable to yield. After the technique was validated on Sandstone, EG&G was tasked by Bill Ogle, Los Alamos Section Leader for Neutron Measurements, to build a simple portable instrument with a polaroid film readout to make the measurement. The resultant instrument was dubbed the Bhangmeter by Ogle.



A Bhangmeter under test, (the black box). The Polaroid film back gave instant readout.

The connotation to Indian hemp was that one would be off his rocker to think such a simple instrument would be useful. In fact, it proved to be very useful, with an accuracy of roughly 15 percent. Bill Ogle had his own personal Bhangmeter to get an early yield number, minutes after the event, and woe be it to EG&G if their official number was appreciably different than his.

In later years, Bill Ogle became a preeminent figure in the Weapons Test community for many years as J Division Leader and later as a consultant to chair the Planning Board, a management forum that discussed a broad range of topics related to testing and its impact on the environment.

Another standard measurement that had its roots in the early days of testing that also became the purview of EG&G was neutron reaction history or Alpha measurement. Bruno Rossi, a Los Alamos scientist, devised a detector and recording system using a modulated sweep on the fastest available oscilloscope to record this ultra-fast signal on the Trinity event. On Sandstone, through the collaboration of NRL (Naval Research Laboratory), LASL, and EG&G, an Alpha system, based on the Rossi measurement, was developed. EG&G was tasked to field the system and take the measurements.

To address the inadequacies of existing available oscilloscopes, the NRL group and EG&G were funded to develop new high-speed cathode ray tubes based on an NRL prototype. This led to a family of traveling wave oscilloscopes, of which EG&G produced well over hundreds of units over the years of the testing program. It wasn't until the last few years of testing that digital techniques became fast enough to replace these unique instruments. This measurement also required the development of fast fluor and photosensor combinations needed as detectors. The detectors were also developed and produced by EG&G. through their collaboration with Los Alamos and based on Los Alamos designs.

An early suggestion by Edward Teller led to another alpha measurement technique. He observed that the prompt gamma signal passing through the air would produce an optical alpha signature. EG&G, working with LASL, built detectors, based on five-foot diameter searchlight mirrors, and successfully recorded "Teller light" during Sandstone.

Eighteen months after the George event, during Operation Ivy, the Mike event was detonated. Mike was an experimental thermonuclear device based on Teller-Ullam ideas. The device had a massive cryogenics system and weighed over 65 tons. Built on the island of Elugelab, it was triggered from a ship located over 40 miles away. One unique feature of the diagnostics was a rectangular wooden tunnel, over 6 feet tall and stretching from the device four miles across the lagoon to the next island. At shot time, the tunnel was filled with helium to provide an optical path for some special instrumentation on the distant island. After the detonation of Mike, with a yield of over 10 megatons, there was not much left of the island other than a large underwater crater. Keeping the pressure on, the Soviets successfully tested their first thermonuclear bomb in 1953.

Beginning with the Mike shot, a two-stage device, the time between the primary and secondary detonations became a critical measurement to be made on all multi-stage devices and was of special importance to the weapons designers.

Barney O'Keefe (front) and Mike Warchol aboard ship during the final countdown for the Ivy Mike thermonuclear detonation at Enewetak.

Several laboratory scientists also observed a strong electromagnetic pulse on test events. After the Ranger series, Sandia had stations at the NTS to observe both the electromagnetic signal and a prompt optical signal (Teller light) coincident with the primary detonation. The electromagnetic signal was so strong, it was also observed at Sandia in Albuquerque, New Mexico. Making these measurements on a multi-stage device also gave the interval time.

One event remained in the company's folklore; the FOX event scheduled for the morning of May 20, 1952. This was a tower shot that counted down to zero and nothing happened. In those days, after a device was armed, the tower elevator was dismantled and removed as part of the security plan. A disarming party was put together, consisting of Jack Clark, the Test Director; John Wieneke, a Los Alamos physicist; Grier, and O'Keefe. Grier and O'Keefe flipped a coin to see who would climb the 300-foot-tall tower with Clark to disconnect the firing cables. O'Keefe lost and got the job. The team cautiously drove out to ground zero, not knowing the cause and not sure if there would be a delayed detonation. They climbed the tower and Clark performed the actual disarming operation while Wieneke monitored his actions and O'Keefe reported by telephone to the Test Director. As was determined later, one of the critical experiments on the event became inoperative and locked out the firing signal as designed. The FOX event was finally detonated the following week.

The testing program in Las Vegas continued to grow. In 1953, eleven tests were conducted. However, the concern over fallout caused committees to be formed to study the future of the test site, resulting in recommended changes for future testing.

During 1953, UCRL fielded their first tests at NTS only six months after opening the new laboratory. The events were named "Ruth" and "Ray", (Ruth and Ray were Herbert York's "honorary" aunt and uncle). They were physics tests of particular interest to Teller. When the dust settled from the Ruth test, the lower portion of the tower holding the device was still standing. This was naturally a source of some ribbing from the LASL crew. After a similar result for the Ray event, the new lab was up and running with successful, innovative designs.

Operation Castle in 1954 started with the Bravo event on Bikini, the first test of an aircraft-deliverable thermonuclear bomb. The firing party for this event included the veteran team of Clark, Grier, and O'Keefe. This was O'Keefe's last operation in which he was planning to have a major nuclear testing responsibility. Working with Germeshausen, he was planning to devote full time to developing the company's commercial activities. Grier, on the other hand, was preparing to devote his full time to the Nevada operations, which now continued year-round. O'Keefe would be heading home after the event with the early records of the experiment.

The group in the firing party also included Harold Stewart, an NRL spectrometrist; Lieutenant Douglas Cochrane, a naval communications officer; an air-conditioning expert; and two Air Force sergeants to operate radios. (Stewart and Cochrane both joined EG&G, in later years.) Gaelen Felt, a Los Alamos scientist, also landed up in the control bunker to handle some last-minute aspects of an experiment he had on the event. (Gaelen Felt later joined EG&G and managed the company's Nevada Operations.)

The control bunker was twenty miles from ground zero on a separate island. O'Keefe gave the countdown. The device detonated and looked good from the observation ships. The group in the control bunker counted down the seconds before the shock wave hit them. Unfortunately for the crew in the bunker, the predicted 6-Megaton yield was exceeded by more than a factor of two. The concrete bunker started moving from the ground shock wave like it was on jelly. This was a new experience, since there had never been an event large enough to create such an energetic ground shock. Then the air shock wave hit, rattling the steel doors on the bunker, and forcing water through the electrical conduits into the bunker. There was no sign of a water wave from the sampling aircraft, but the group waited 15 minutes before opening the watertight steel bunker door to look outside.

While outside, the radiation level started to build rapidly, and a whitish chaff started falling from the sky. The group bolted for the bunker. Within minutes, they were estimating the radiation level outside to be about 5 R per hour. At that rate, a person could receive the maximum allowable yearly dose in less than an hour. Soon it was up to 60 R per hour outside, too hot to evacuate the bunker. It was more than eight hours before helicopters could be sent in. They made makeshift rad-safety suits out of bed sheets and masking tape and managed to accumulate only a minor radiation dose.

After Operation Castle, there was almost a year's respite from testing while LASL and UCRL digested the information from the Pacific tests and prepared a variety of tactical weapon devices for testing in Nevada the following year. Grier moved to Nevada to devote himself full time to continental weapons test activities. With Grier's move, the company reorganized, dividing operations into a Western Division headed up by Grier as executive vice president, and an Eastern Division headed up by O'Keefe as vice president. Under this structure, Germeshausen became president, and Edgerton continued as Chairman of the Board. Germeshausen and O'Keefe tried to devote most of their time to the development of commercial activities. By the end of 1954, the company had 190 employees, 50 of whom were in Nevada.

In 1955, the tube production group that built spark gaps, cathode ray tubes, and flash tubes was separated from the research group. Many of the switching devices were derived from original proprietary innovations of Germeshausen. From its origins as an NRL prototype, the traveling wave cathode ray tube (CRT) and the oscilloscope models using the EG&G CRT became increasingly important diagnostic instruments for the testing program.

Germeshausen (right) holding an early version of the traveling wave CRT, pictured with Doc Edgerton.

While the company was moving ahead with commercial diversification, the testing program was still the prime responsibility. In 1955 Grier had his hands full with a test program calling for fifteen detonations in Nevada with a scope of work that included timing and firing, high-speed photography, and neutron reaction history, along with any other experiment devised by the Laboratories.

While O'Keefe still had responsibility for the Pacific tests, on May14,1955, the Navy wanted to do a 30 kt nuclear deep underwater test, the Wigwam event. For EG&G, this event required only timing and firing, and O'Keefe expected to be away from Boston for only 12 days. The event logistics were deployed out of San Diego. A fleet, including an aircraft carrier, destroyers, and a ship towing a 6-mile-long cable with test vessels strung along its length sailed to the test area. The event was planned for an area in the Pacific that is typically very calm. Unfortunately, an earthquake in the Aleutian Islands caused high seas in the test zone. The high seas were creating havoc with the towed vessels, raising concern whether they could survive a schedule delay. The event had to go on time. What should have been a simple firing party trip to the shot barge became very challenging, dealing with high seas and a bobbing barge. Even so, the arming was successfully accomplished, and the event went on schedule. The device was detonated 2,000 feet below the surface. The ocean depth in the area was about 16,000 feet.

For O'Keefe to keep to his tight schedule, he had to ride a breeches buoy from the carrier to a destroyer that was heading back early. As he was bobbing across the ocean, he was wishing he weren't in such a hurry.

British Test Program

The British became the third nuclear power in the fall of 1952. They tested their first atomic bomb, code named Hurricane, aboard a ship just off Trimouille Island in the Monte Bello Island group, off the northwest coast of Australia. The test was to simulate the effect of a nuclear attack on London harbor.

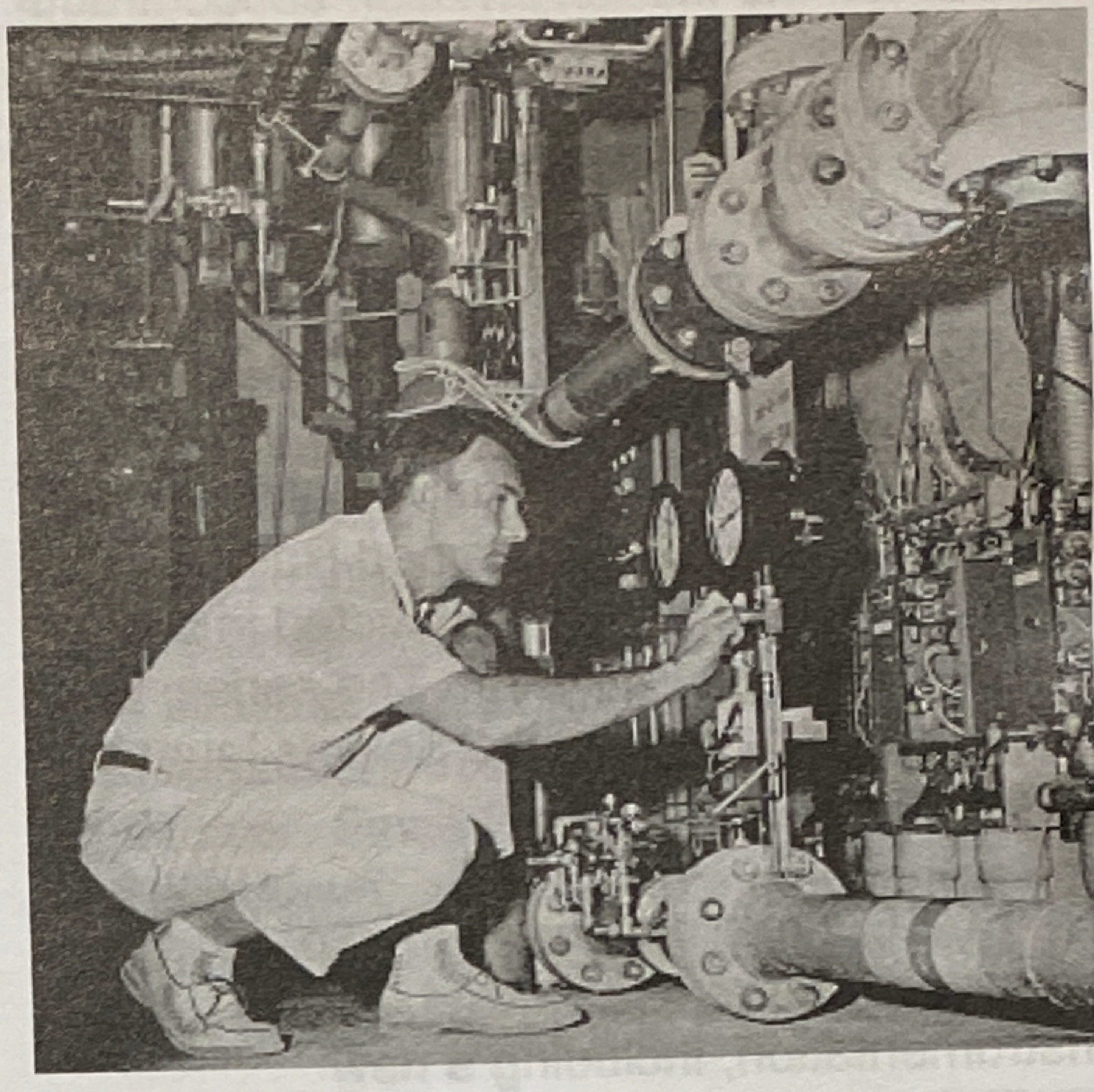
The British scientists took 8 weeks by ship to travel to their test site due to security concerns about travelling through the Suez Canal. Later, they developed Christmas Island for their testing location, along with conjointly testing with the US at the NTS.

The British scientists that participated in the Manhattan Project were significant contributors to its success. Unfortunately, one the team members, Klaus Fuchs, turned out to be a Russian spy and was later arrested and sent to prison in England his role in providing technical information to Russia.

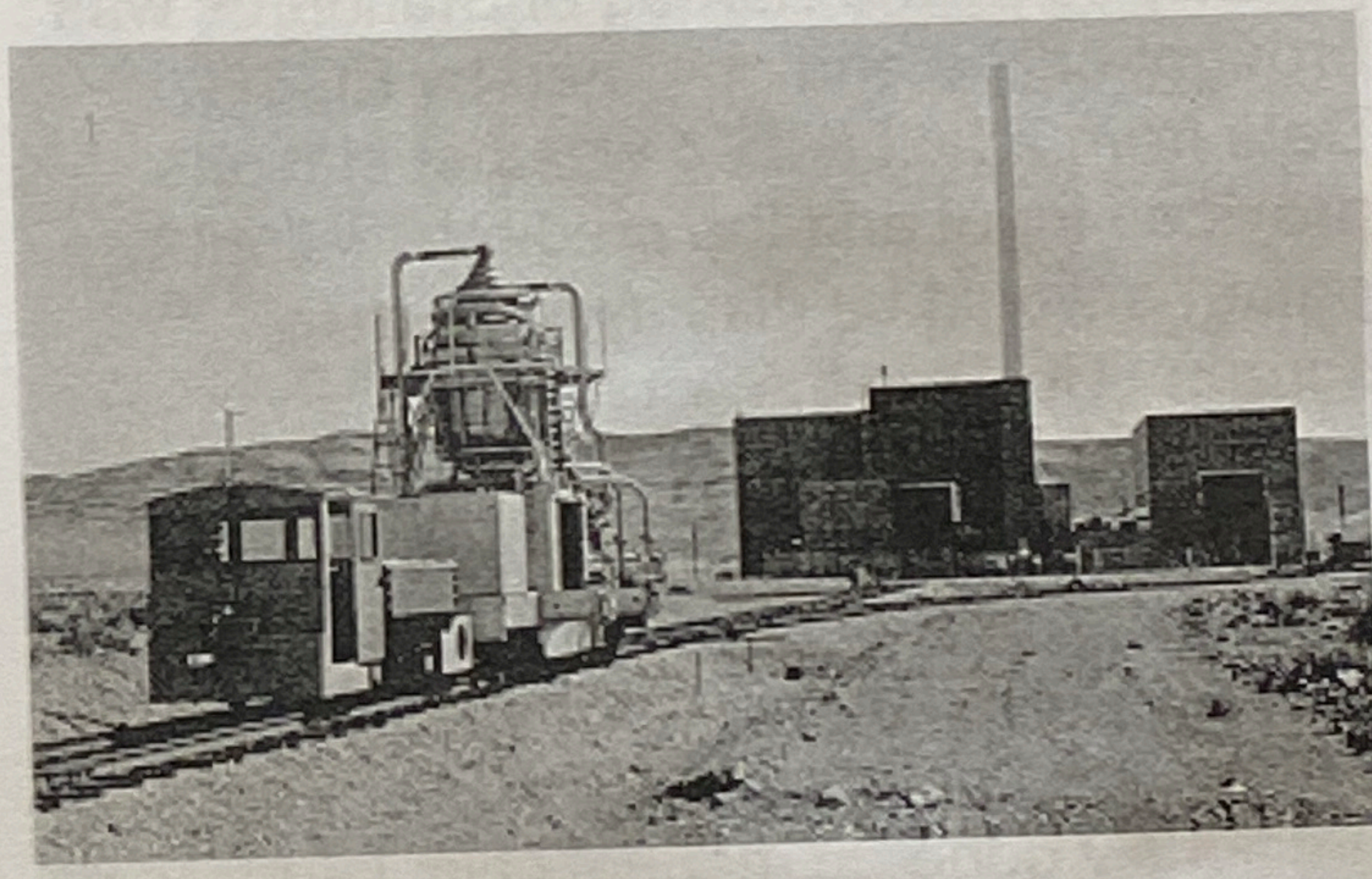
Rover

1956 saw the inception of Project Rover for the development of a nuclear rocket engine for interplanetary travel. The Space Nuclear Propulsion Office (SNPO), a joint AEC-NASA collaboration, managed the project. The entire southwest corner of the Test Site had been set aside for the testing of nuclear systems for the project.

LASL had the responsibility for the research and development of the prototype reactor/engine and sub-contracted the nozzle and hydrogen cryopump to Rocketdyne.



Ralph Freedman inspects gauges and associated EG&G pressure module in Kiwi A test cell.



One of the Kiwi series reactors is being moved into test position.

Because of the relatively unshielded reactor, instrumentation was required which would enable data to be collected and controlled from two miles away. EG&G installed, calibrated, and maintained most of the electrical equipment and electronics in the test area. The company also provided common support facilities for all organizations participating in the Rover tests at the NTS. These facilities included television, meteorological telemetry, technical photography, airborne radiological measurements, range timing, and Standards Laboratory facilities.

Project NERVA was the follow-on to Rover, taking the best Rover engine to the next phase. Aerojet-General Corporation was the prime contractor for NERVA and EG&G had the instrumentation subcontract.

Back to Weapons testing

Operation Plumbbob was conducted at the NTS during 1957 and included 29 nuclear test events in a variety of configurations. The first fully contained underground test, code named Rainer, a UCRL experiment, was conducted in a tunnel under Rainer Mesa. The series ended three days after the Soviets launched Sputnik.

EG&G's role continued to expand, developing more specialized instrumentation, including a new oscilloscope and a light weight Zero Rack for balloon shots. A fallout computer developed by the Bureau of Standards was brought online and operated by EG&G. Data from a half dozen weather stations provided input and the predicted fallout patterns would be displayed on a TV screen. Besides the established instrumentation role, EG&G did much of the data recovery, scientific film processing, and data reduction. During the Plumbbob series, a new electronic computation system came online to replace computations previously done on manual calculators. The predominant computer age was still off into the future. Also in 1957, EG&G purchased its first corporate aircraft, a Beechcraft Bonanza. The plane was based in Las Vegas and was used to supplement commercial air travel. In this year the company reached 500 employees.

Collecting data from nuclear explosions led to a continuing stream of instrumentation development and refinement. Most everything had to be specially built, as there was very little overlap with the requirements for other types of scientific measurements.

Scientific photography was also in its infancy. Extracting diagnostic data from photographic images became a key area of expertise for EG&G. The photographed images of fireball growth that led to yield determination were critical measurements. The quality of film needed to be assured and film processing required precise sensitometric control. EG&G designed and used sensitometers for this purpose. Calibrated sensitometers led to the use of film as a radiometric sensor. The sensitometer also resulted in a new commercial product line for the company.

Late 1950s ad for the Mark VI sensitometer demonstrated by Beverly Simmons.

In the spring of 1958, the Soviets completed a major test series and immediately started to campaign for a test ban. They issued a decree prohibiting further nuclear testing provided that other nations did not test. The likelihood and impact of a test ban was well understood by the company. EG&G obtained a significant position in Project Rover, focused on the development of a nuclear rocket for deep space travel, which helped it maintain staffing levels. On the commercial side, the company developed a commercial version of the traveling wave oscilloscope, an expanded array of flashtubes, and new electro-optical equipment.

The stumbling block to a test ban treaty with the Russians was verification.

President Eisenhower recommended forming a technical conference to develop the requirements for verifying the ban. The Russians reluctantly agreed, and the US was able to get off the last test series (Hardtack II) before the ban.

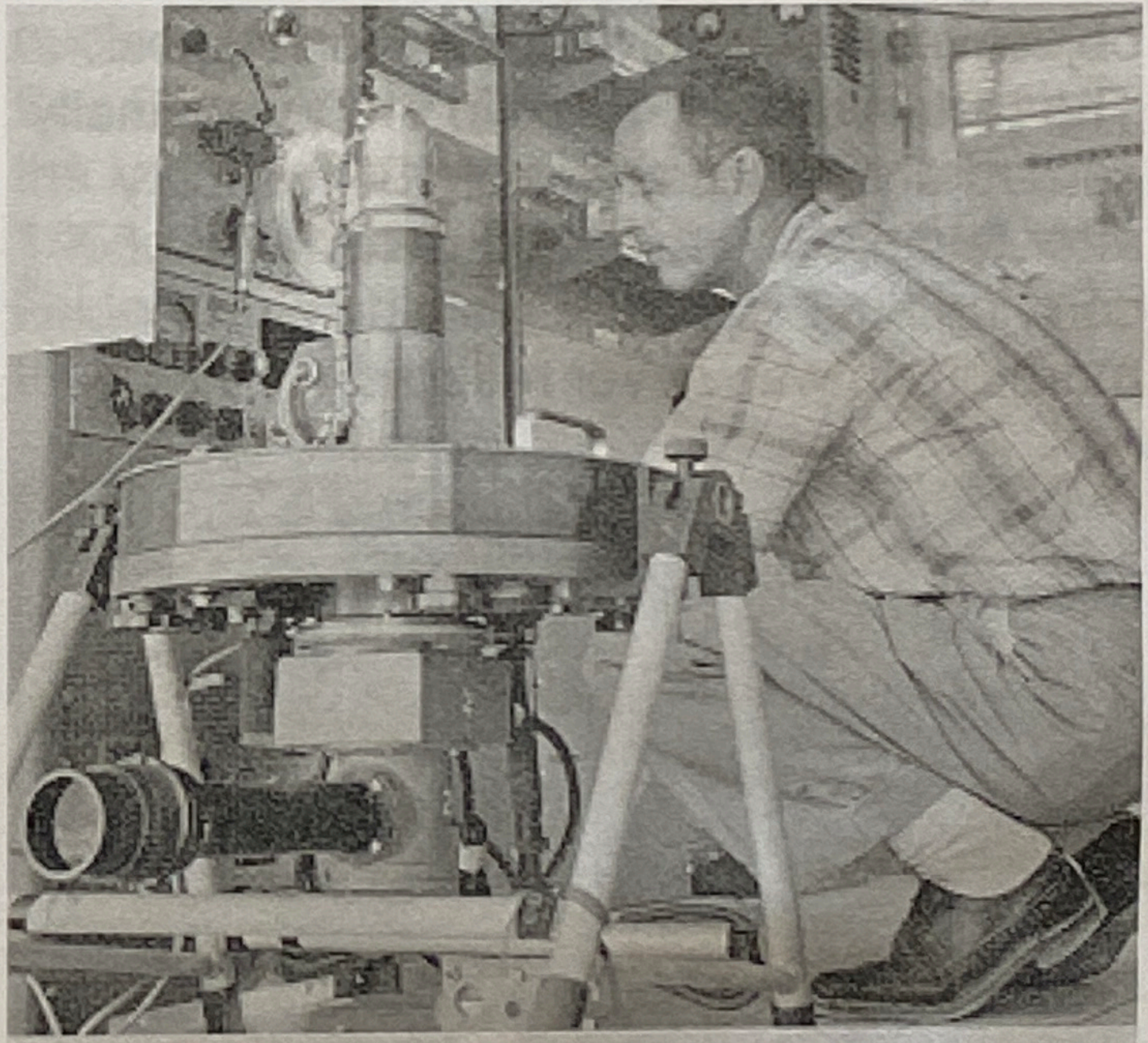
Prior to the test ban, the US conducted two major operations, Hardtack I in the Pacific, including 35 events using the Bikini and Enewetak Atolls, and Hardtack II at the NTS, including 37 events.

This meant two major full-scale programs. The Laboratories began to run short of test managers. When they heard that O'Keefe did not intend to participate in the field operations, he was recruited to accept an assignment in the scientific task group for Operation Hardtack I in the Pacific. O'Keefe became scientific commander for the Bikini operations, taking another leave of absence from the company. During Hardtack, the United States conducted 72 tests, including the first two high altitude shots detonated from rockets launched from Johnston Island. The high-altitude shots were originally planned to be launched from Bikini but concerns about flash blindness in the native population led to the launch relocation.

The first rocket shot, code named Teak, was a megaton-range warhead detonated at an altitude of nearly 48 miles. The second, code named Orange, also in the megaton-range, was detonated at about 27 miles. The fireball from the Teak event rose to a height of 90 miles and was clearly visible from Hawaii, seven hundred miles away. In addition to blocking radio communications over a radius of several thousand miles, the event created an artificial aurora that could be seen from the Samoan Islands, two thousand miles away. Due to problems with the rockets, the detonations did not occur where they were expected, which resulted in a loss of some early time photographic data.

A few weeks later, three rocket borne nuclear tests with yields of 1-2 kt were detonated at altitudes from 100 to 400 miles over the South Atlantic Ocean. These three events, Project Argus, were designed to answer questions about potential radar and radio interference, since Teak and Orange were neither high enough nor in the right point in space.

Operation Hardtack I also saw the introduction of a new EG&G high speed framing camera capable of more than 18,000 frames per second. The camera used a rotating mirror to sweep the image past 36 relay lenses, forming images on a fixed filmstrip. An exploding foil shutter was used to prevent overwriting the first set of exposures. Since the events were typically fired pre-dawn, only a simple mechanical shutter, opened with a timing signal, was needed to open the optical path.



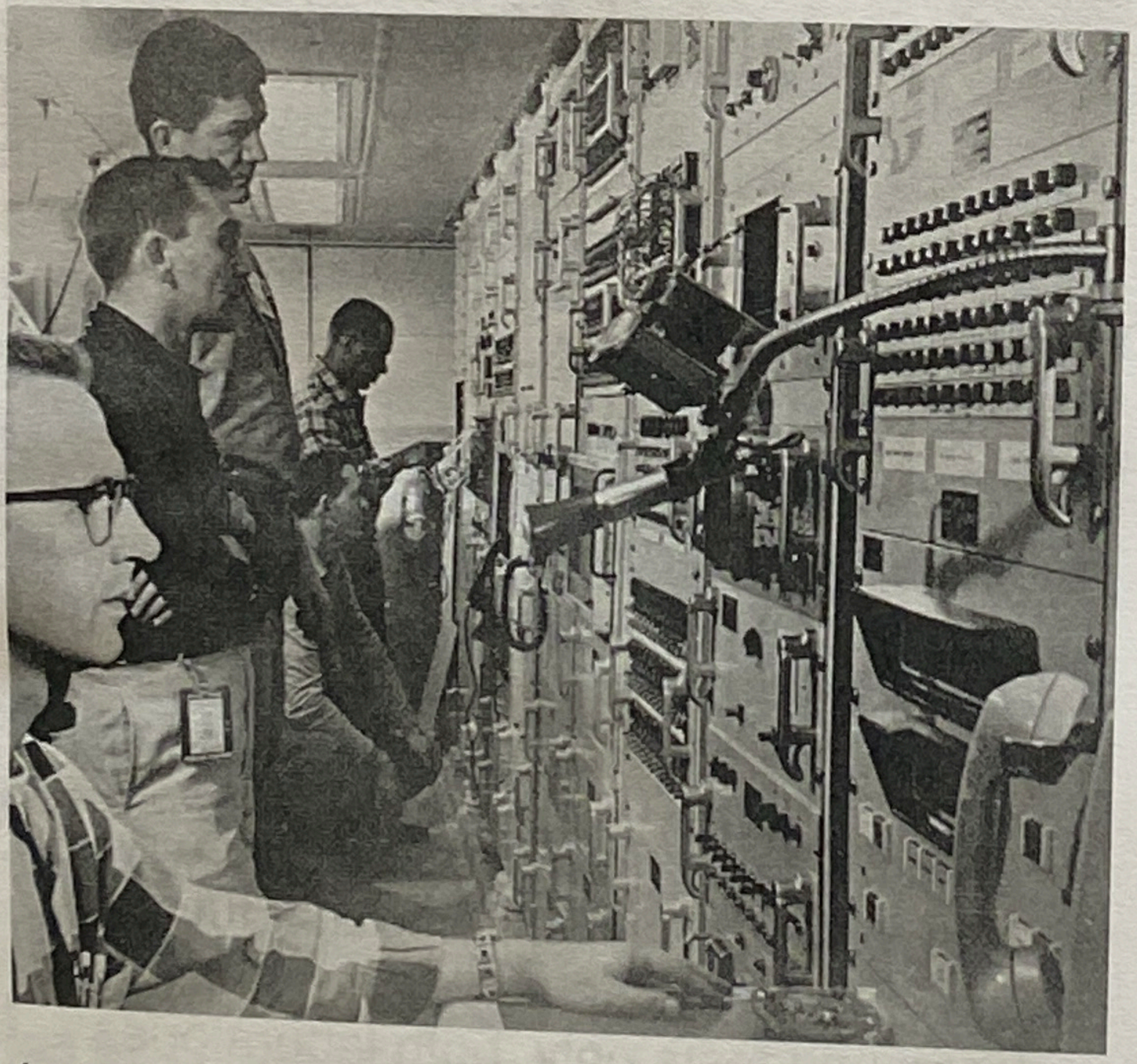
Tom Devlin adjusting the framing camera during Operation Hardtack at the NTS.

With the potential of a moratorium on the horizon and the likelihood that future testing may be restricted to contained underground tests only, both laboratories used some of the Hardtack II tests to look at containment concepts. LRL conducted several tunnel shots under Rainier Mesa using new containment concepts, while LASL conducted safety shots in vertically drilled holes on Yucca Flat to test stemming techniques.

Plowshare

In June 1957, Project Plowshare was organized as part of a worldwide Atoms for Peace effort. The project, led by LRL, was to develop and explore the non-military use of nuclear explosives for peaceful construction and scientific purposes. With a high probability of a moratorium looming on the horizon, LRL saw the potential in Plowshare for maintaining nuclear design capability. Edward Teller, LRL Director, believed that Plowshare events would be permitted even during a moratorium.

The first test, Gnome, was scheduled for the summer of 1959, in New Mexico. A 10 KT device was to be detonated at the bottom of a shaft, 1200 feet deep, in an underground salt bed. One of several objectives was to produce radioisotopes. The test, reduced in size to 5KT, was finally carried out in December of 1961, shortly after testing was resumed. The hope of carrying out Plowshare tests during the moratorium was never realized.



Inside a typical EG&G mobile T&F station for the Plowshare event Gnome. Dave Smith and Nubar Hagopian are at the consoles.

Issues over trace radioactivity coupled with some disappointing results brought the program to an end by the mid-1970s, but over the life of the program, 35 Plowshare events were conducted.

The Moratorium

On August 22, 1958, President Eisenhower announced a one-year moratorium to begin October 31, 1958. In response, Khrushchev agreed to take a step toward a possible test ban but didn't initially agree to start moratorium discussions. Blanca, the last US test before the moratorium, was conducted on October 30.

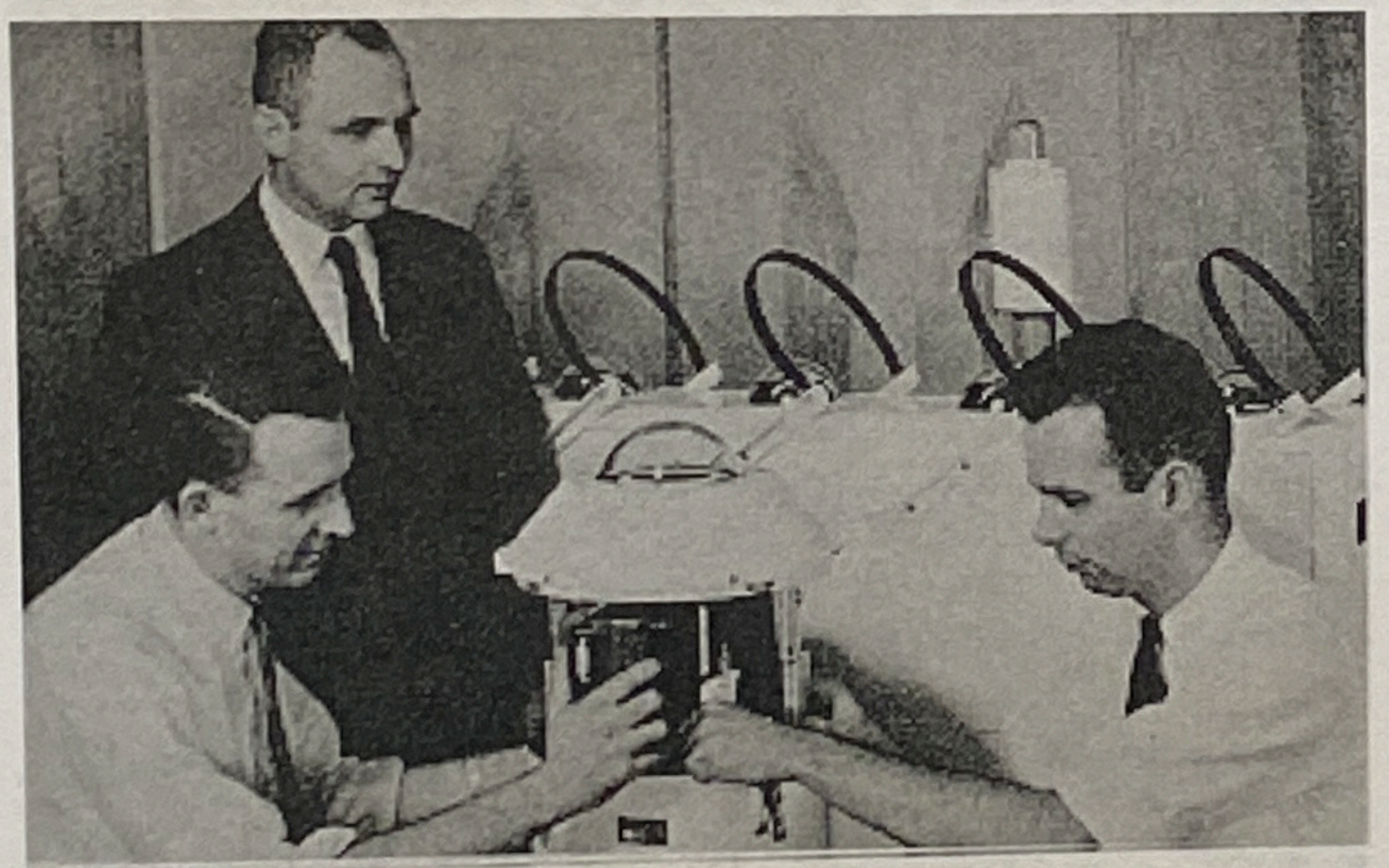
The Soviets instead started a vigorous test series on September 30 and conducted 19 detonations through October 25, then fired 2 high altitude rocket events in early November. They then also started an indefinite moratorium.

The technical conference on verification between the Russians and the US concluded that verification could be accomplished, which led President Eisenhower to a meeting to negotiate a permanent end to nuclear testing.

During the first year of the moratorium, the labs believed that testing would resume, but most likely, only with contained underground tests and possibly at very high altitudes. Some planning and construction work was carried out for the NTS, but funding was always an issue. After the first year, the potential of using the Marshall Islands again was dwindling, along with the infrastructure to support testing in the Pacific. An overriding concern had to do with developing methods to catch the Soviets cheating, either while negotiations were underway or after terms of a treaty were established.

I arrived at EG&G in Boston in June of 1959, as a newly minted engineer from Stevens Institute of Technology. I was hired by the group that was trying to develop commercial products from some of the test program instrumentation. We built a commercial version of EG&G's traveling wave oscilloscope. As I remember, it was not a particularly big seller. There weren't very many people working in that time domain with a requirement for a single sweep oscilloscope. The advent of sampling oscilloscopes really shrunk the market.

My first contact with the Los Alamos Scientific Laboratory was with Don Westervelt. He was an energetic scientist with J-10 who had garnered funding for what would develop into part of the Vela Program. J-10, the Los Alamos Group led by Herman Heurlin was primarily interested in high altitude nuclear weapons effects. Westervelt came to EG&G for engineering support. We had to take his conceptual ideas and create an operational electro-optical system for the detection of nuclear explosions in outer space. Our group became completely involved in this effort. The resulting system was named "Z System" by the Air Force who funded the project. The system was designed to detect the unique fluorescence signature from an outer space nuclear explosion.



Ed Sayce and Charlie Philips adjusting an all-sky camera, while John Champeny looks on. A rack of Z System detectors with sunshades is located behind John.

The Vela Program was designed to cover the concern that the Russians would attempt clandestine testing during the moratorium. The program had several sub-elements to cover such things as seismic detection, decoupling, and outer space nuclear explosions detection. EG&G had a significant role in the development and field testing of the original air fluorescence detection system for outer space detonations and a direct view system for atmospheric detonations. Both systems were deployed by the Air Force, with EG&G support, at various sites around the world. These systems provided coverage while satellite systems were being developed at Sandia. The Vela Satellites eventually formed a world-wide network that could detect gamma radiation from an outer space nuclear event or record the optical signature of an atmospheric nuclear test.

Also, as part of Vela Uniform, research started on whether it was possible to decouple a nuclear detonation from seismic detection. In 1959, a small spherical cavity was mined in a salt dome near Winnfield, Louisiana, and was used to see if a large chemical explosion detonated in the cavity would be more difficult to detect. The decoupling concept seemed feasible which led to a series of nuclear tests after testing was resumed. Two of these follow-on nuclear tests were carried out in the Tatum Salt Dome, near Hattiesburg, Mississippi, the last of which was Sterling in December 1966. EG&G developed, instrumented, and fielded mobile timing and firing trailers for these off-site events.

In 1958, the Las Vegas Operation formed a nucleonics group, headed up by Sanford (Sandy) Sigoloff. The group worked on an Army Signal Corps contract to determine the effects of nuclear radiation on electronic components. A year after the formation of the nucleonics group, Sigoloff relocated the work and most of the people to a newly acquired facility in Santa Barbara, California. The company opened this third location in Santa Barbara with the intention to provide R&D support to the Las Vegas Operation. It was felt that in Santa Barbara, the company could attract scientific and engineering talent not accessible to the present Las Vegas location. To support the effort of the nucleonics group, a source range was constructed on the property to provide standard radiation environments for the calibration of detectors.

In 1959, EG&G reached from ocean depths to outer space. Doc Edgerton designed and helped field an underwater camera and light source system that was first tested at a depth of 25,000 feet, exploring the Romanche trench. The system exposed a 500-foot roll of 35-mm film at one exposure every 12 seconds. The camera's data chamber recorded depth, pressure, and time. The system also included sonar, to give the operators the distance to the ocean floor. This test was Edgerton's introduction to Jacques Cousteau and that began a long-term collaboration between the two men. The company also started to produce a line of underwater sonars called Boomers and Pingers, depending on the energy of the output pulse. The venture into outer space was achieved with a NASA contract to design a high intensity flash system for use in a geodetic satellite, allowing for precise optical tracking. The satellite, ANNA, achieved orbit in October 1962 and was easily visible with binoculars in the night sky, pulsing once every 5.6 seconds.

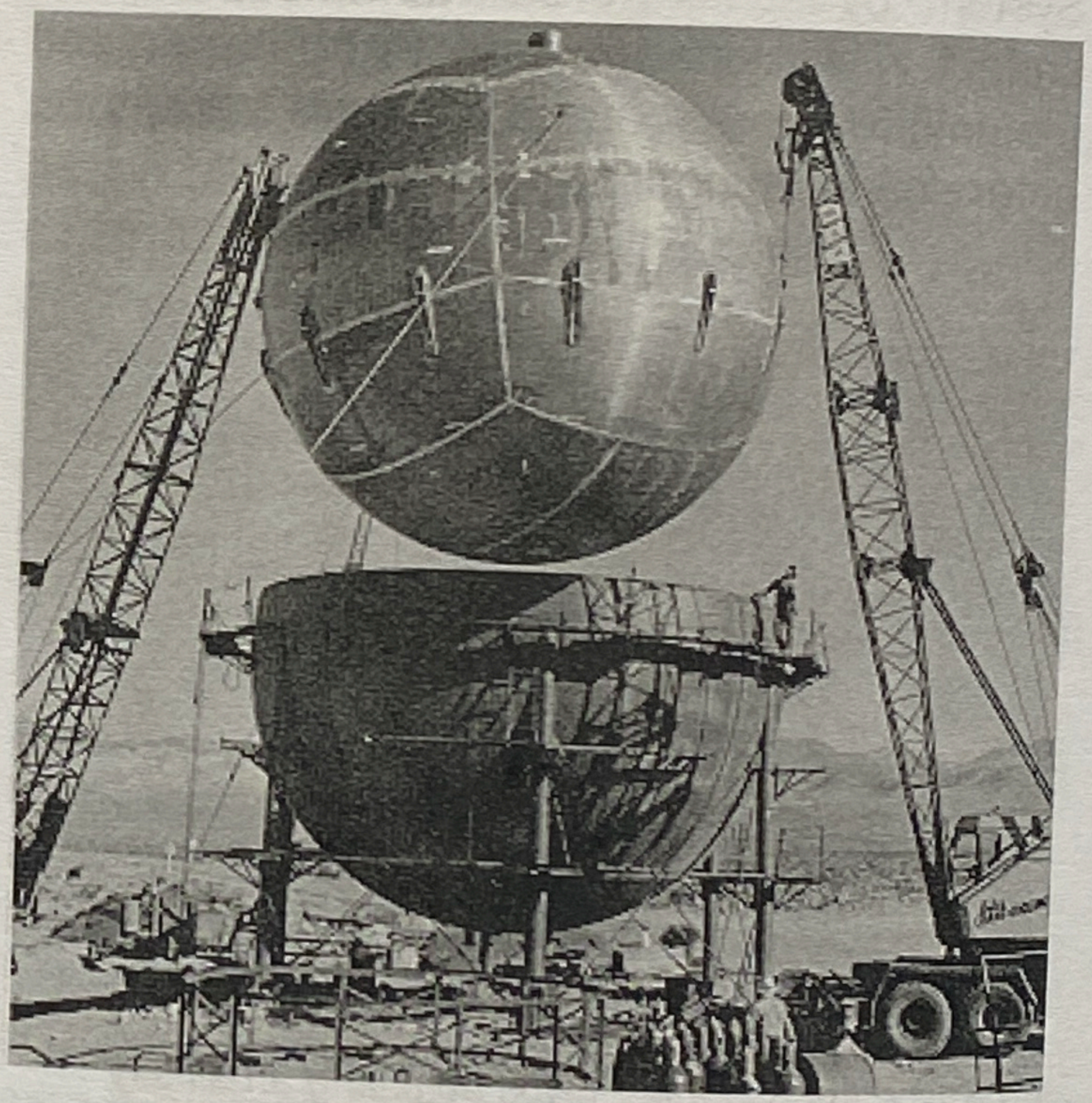
Also, during 1959, the company purchased all the patents and patent applications of the three founders. In total, there were more than 140 patents.

The closely held company broadened its ownership with the public sale of 100,000 shares of common stock in 1961. However, the majority ownership was still held by the founders. Also in 1961, another EG&G location was opened in Salem, Massachusetts, when the government requested EG&G assume the CBS Electronics development and production of krytrons, a nuclear weapons component. The Salem expansion added some 90 new employees and $1M in sales.

Project Rover

Project Rover was set up to develop a nuclear-thermal rocket and ran from 1955 to 1969. It began as a project to develop an upper stage for an ICBM. After Sputnik triggered the space race, the project interest evolved to space travel. The lead laboratory was Los Alamos.

The company's role in Project Rover started a few years later when NTS became involved. Originally, most of the equipment and design engineering was done in Boston. A Reactor Engineering Department was established in Las Vegas to take over the lead on the project. The department was organized into an instrumentation group, a data reduction group, and a physics group. Test Cell C, which contained substantially larger hydrogen Dewars and high-pressure hydrogen gas storage than those at test cell A, was brought on-line at NRDS (Nuclear Rocket Development Station) at NTS for the next series of Kiwi reactor tests. Between 1959 and 1964 eight Kiwis were tested



Assembling the 100,000-gallon dewar for the Kiwi Test Cell.

Photochromic Goggles

A small but interesting government contract was started in 1960. The company was asked to develop a means of automatically shutting out the sudden flash of a nuclear detonation before eye damage occurs. The system, for use by pilots, was finally completed in 1964. The photochromic goggle system would automatically eclipse the pilot's vision within 100 microseconds of the nuclear flash and then automatically open within a few seconds. Additional applications of the patented technology included use in submarine periscopes and tank gun sights.

Air Force Pilot wearing the photochromic goggle system.

Also in 1961, Gaelen Felt joined the company as manager of the EG&G Las Vegas Operations. In Boston, Edgerton was working with an MIT professor on the development of the MASER, Microwave Amplification by Stimulated Emission of Radiation. EG&G flashtubes were used to optically pump a synthetic ruby crystal to produce a coherent, monochromatic light beam. Later, "microwave" was dropped, replaced by "light", to produce a more familiar acronym, LASER. EG&G flash tubes were very popular drivers for early laser systems.

French Nuclear Tests

The French conducted their first nuclear test in the Sahara Desert in 1960, joining the United States, Russia, and England as a nuclear power. This was the first atomic test since the three nuclear powers halted weapons testing in the fall of 1958. France followed up with three more tests; the last French test of the series occurred on April 25, 1961. The Russian Ambassador at the treaty negotiations stated that the French tests "places the Soviet Union in a situation which may compel it to resume nuclear testing."

The French later moved their testing program to the Pacific, where they conducted 193 tests, including 41 atmospheric tests, at Moruroa and Fangataufa atolls in French Polynesia.

The Resumption of Nuclear Testing

The Soviets never could agree on the details of the inspections that would assure compliance with a nuclear testing moratorium. After three years of stalling, while a disarmament conference was in session, August 30, 1961, the Soviets announced their intention to resume testing. Their first test occurred on the next day, September 1, in Semipalatinsk. The series consisted of 57 tests, including 11 high altitude rocket launched tests, one underwater event and one tunnel event. There were several megaton detonations, one event, "Tsar Bomba" had a yield of over 50 megatons, the largest atmospheric test ever conducted. The series ended on November 4th.

During the soviet test series, the worldwide complex of Z Systems was monitoring the skies for high-altitude events. I was deployed to one of the stations in Norway, north of the arctic circle, early October, swapping out with another EG&G crew and stayed there until the end of Russia's test series. Sid Stone, a LASL physicist, was the lead scientist. The station was actually an instrument trailer parked on a hill on a NATO base.

It was clear that the Soviets never stopped test preparations and caught the U.S. unprepared, but not totally unready. President Kennedy announced on September 5 that the U.S. would not resume testing if the test ban was reinstated. but stated that the test ban proposal would only remain on the table until September 9. The offer was ignored by the Soviets and U.S. began testing within a week.

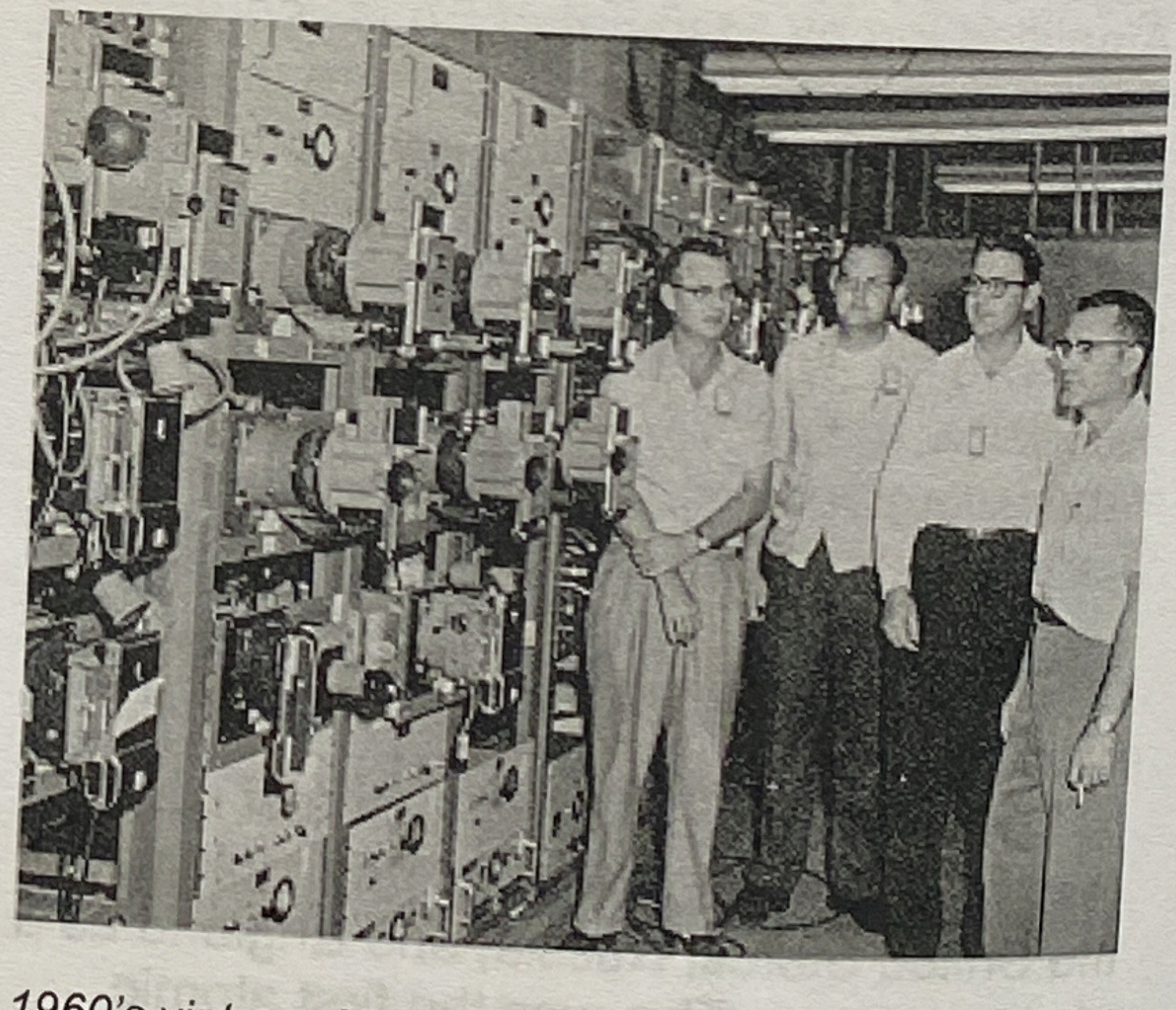
During the moratorium, REECo built two principal tunnel complexes at the NTS with approximately 20,000 feet of tunnels and side drifts in three main tunnel complexes. In Area 3, they also drilled four vertical holes 500 feet deep in anticipation of resumed testing.

The laboratory test organizations, EG&G, REECo, and other contractors had small field crews in Nevada conducting chemical explosive experiments, low power nuclear simulations, and the nuclear rocket motor experiments of Project Rover. With this cadre, the U.S. was able to start a series of low yield tests within two weeks of the first Russian test. The Administration wanted a test by September 15, and both labs were ready. LRL had a tunnel shot prepared and LASL had a vertical shot ready. The LRL tunnel shot was selected to go first, since it was of higher yield. The LASL shot went the following day. The first tests had minimum instrumentation and were carried out more for political effect than science. EG&G and the other contractors were able to staff up rapidly and had a full scale, low yield test program underway a few months later. In addition to tests conducted in shafts and tunnels, there were also some shallow buried shots. The concern for containment was that the radiation remained within the confines of the NTS. Planning and preparation for a balloon shot took place during the first six months of the NTS Test Program but was cancelled at the last moment.

Early sixties photo of Bernard Murphy at the EG&G T&F console.

In October 1961, the AEC activated a field office in Las Vegas with 26 employees to support the resumption of testing and the increasing nuclear propulsion development responsibilities. In April of 1962, the field office was elevated to an operations office, forming the AEC Nevada Operations Office (NVOO). Jim Reeves was appointed Manager.

The testing community-- the laboratories, contractors, the AEC, and the DoD, --moved with incredible swiftness from a planning mode to implementing a new test program with a variety of restrictions and requirements. Contained underground testing was clearly the future and the first few tests showed there was much to learn. Alpha measurements benefited from the invention of the Compton detector by Lee Neher, a Los Alamos scientist. Yet, how best to make the measurements underground still needed to be worked out. Concepts for making hydrodynamic yield measurements on underground shots were still being developed, and there were problems to be resolved with the use of radiochemistry on underground tests.



1960's vintage Alpha system. Posing are Bill Poe, John Trabert, Joe Sedlmeyer, and Ernie Hopkinson.

After the resumption of testing, employees were being hired in Boston alone, at a rate of more than 50 per month. Soon there were more than 1300 EG&G employees of which more than 500 were in Nevada. Work for the AEC still made up about 75 percent of sales, with commercial sales approaching $ 2M per year.

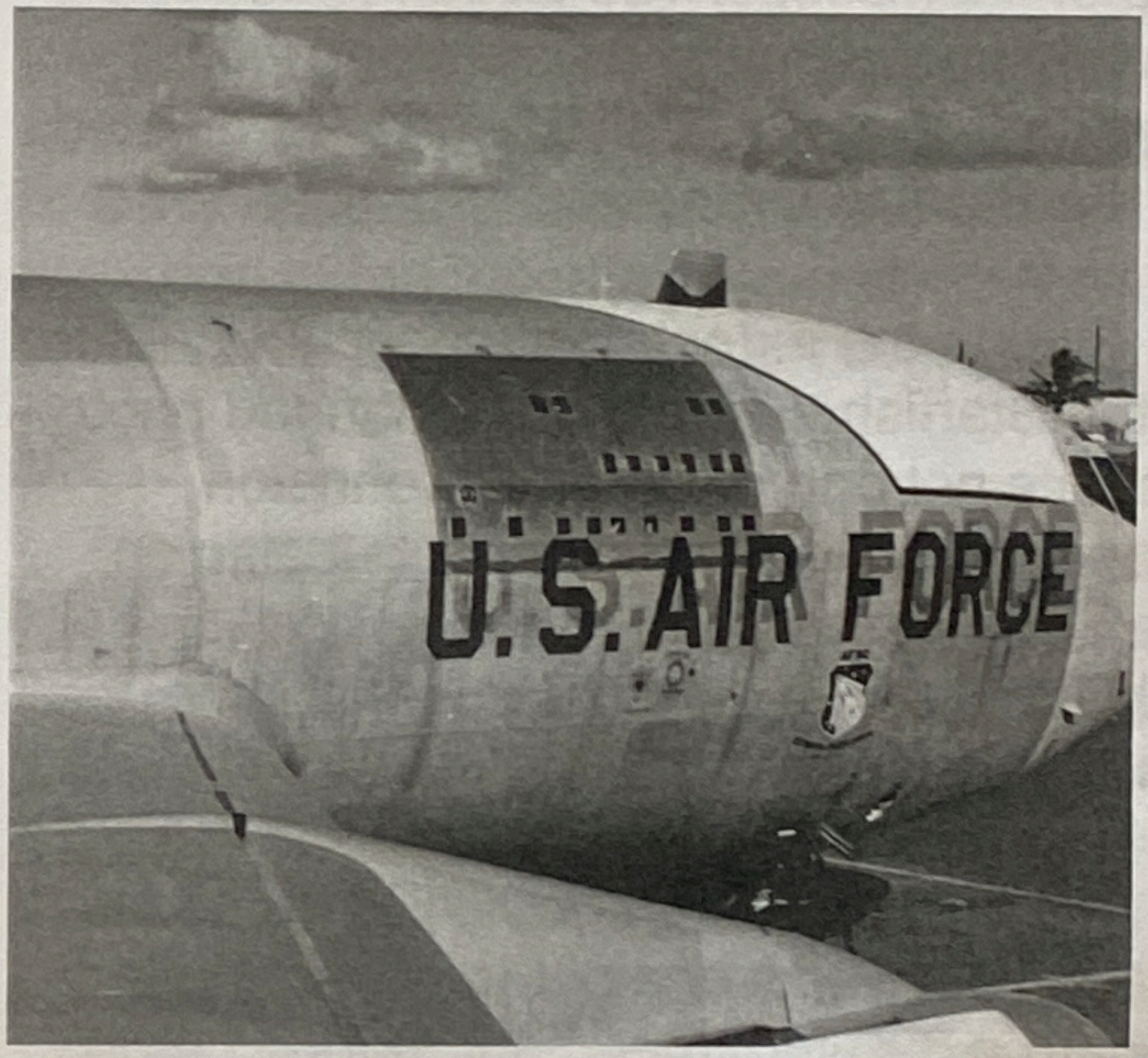
When testing was resumed, the decision to include atmospheric testing was motivated by the concern that the Soviets were getting too far ahead in developing high-yield weapons but restarting a high-yield atmospheric testing program was a difficult problem. Not only was there no Pacific test organization, but also the previously used locations, Enewetak and Bikini Atolls were now part of the Marshall Islands Trust Territory and further use was out of the question. Johnston Island was still available for rocket launches, but it was too small for the planned testing. A British territory, Christmas Island, a thousand miles south of Hawaii, which the British used for their own high-yield tests, became the site of choice. The British agreed to our use of Christmas Island in February 1962. By the end of March, there were 1,500 people on the island, and a full-scale test program was scheduled to begin in April.

Again, there were two full-scale test programs, one in Nevada and one in the Pacific. Due to the three-year moratorium, there was a lack of trained testing personnel, particularly in the military and government laboratories. During the moratorium, EG&G was developing, building, and field-testing systems to detect clandestine nuclear testing as part of the Vela program. EG&G was also out at Enewetak Atoll, operating photo stations to record the reentry of long-range missiles fired from the west coast. This work, along with diversification into other programs, allowed the company to maintain most of their experienced people and EG&G was asked to take on a heavy load for the Pacific Operation, code named Dominic.

Operation Dominic

During Operation Dominic there were 36 events in the Pacific, 29 airdrops, 6 rocket launched events, and one underwater event. Twenty-four of the airdrops were in the Christmas Island area. The series ran from April 1962 with the Adobe event at Christmas Island, to the Tightrope event, in November, a high-altitude rocket event launched off Johnston Island.

The base of operations was Hickam Air Force Base on Oahu Island. The diagnostic aircraft, KC-135's and C-130'S, were based, prepped, and launched from there. Quonset huts and trailers were along the apron for the experimenters to prepare the cameras and equipment for the tests. There was a compound setup with a film processing lab and trailers for the analysists. Thousands of feet of film were processed from each event. The analysists would immediately read the film from the high-speed framing cameras to determine the hydrodynamic yield.



Window array on one of the Dominic KC135's

There were two B-52 bomber aircraft available for the test series. They were prepped, loaded, and launched from the Barber's Point Naval Air Station, about twenty miles away.

I was deployed to the Pacific during Operation Dominic, spending most of my time at Hickam Air force Base. Our instrumentation was mounted aboard one of the specially configured KC-135 aircraft that flew us down to the testing area. We operated photographic, electro-optical and electro-magnetic equipment while flying orbits around the drop area in the test range. I remember that after detonation, we would turn tail and head off in the opposite direction. We would try to guess when the shock wave would reach us, giving the aircraft a shake.

I also worked at stations on top of Haleakala on Maui and Mona Loa on Hawaii, at Canton Island, 2 degrees south of the Equator, and shipboard anchored off Johnston Island.

Of all the tests, the high-altitude events were the most spectacular. One of them, Starfish, 1.4 megatons detonated at an altitude of 270 miles over Johnston Island on July 9, 1962, lit up the night sky from Hawaii to Australia. On the popular front, Life magazine published a fireball photo of one of the Pacific events on the cover of one of their issues. The issue included several photos in the article along with a nighttime photo of Waikiki eerily illuminated by the Starfish event.

Due to the extent of the optical signature of the Starfish event, EG&G manned photo stations not only on aircraft, Johnston Island, and Christmas Island, but also on top of the Haleakala and Mona Loa volcanos, on American Samoa, and on Canton Island.

During part of the High-Altitude series, I spent 45 days as one of the experimenters aboard a 300-foot merchant marine cargo ship leased for the operation. I had an instrument trailer strapped atop one of the cargo holds. We were anchored off Johnston Island for the duration. We arrived on site after Starfish. For that event I was aboard one of the KC-135's. Starfish was certainly the most impressive visually, but from Johnston Island, one of the aborted Bluegill events had added drama with rocket debris falling from the sky, falling into the lagoon and the ocean around my ship. Fortunately, the debris fell harmlessly into the ocean.

At the same time as the Pacific operations, there was also a robust test schedule of weapons development, weapons effects, and Plowshare tests at the NTS. Three days prior to the Starfish event in the Pacific, on July 6, the Plowshare test, Sedan, created a crater 1,300 feet across, at the NTS. With a yield of 104 kt, this was the largest thermonuclear device to date detonated in the Continental United States.

The company made a significant organizational change in 1962 with the creation of a new office of Senior Vice President, filled by Herb Grier. The new office was responsible for overall testing activities, including long range planning. Barney O'Keefe assumed operational responsibility for both the eastern and western divisions and Gaelen Felt was named Chief Operating Officer reporting to O'Keefe. Felt stayed in Las Vegas and continued to play a key management role there.

Meanwhile, negotiations continued for a comprehensive test ban, but inspections continued to be a stumbling block with the Soviets. The only common ground that could be reached was a cessation of nuclear tests in the atmosphere, in outer space, and under water. That became the basis of the limited test ban treaty that was ratified in the Senate by a vote of 79 to 9 on September 23, 1963. From that date, only underground tests with a yield limit of 150 kt, could be conducted. Verification of the yield of the larger underground tests became an issue that needed to be addressed. The US continued testing until September 23,1992, when the US voluntarily suspended all nuclear testing. The Divider event was the last test detonated.

When US testing was halted, there was an event in final stages of preparation, Icecap, a joint US/UK event. The British removed their device and brought it home, but the instrumentation rack remains in the tower to this day and is a feature on the typical NTS tour agenda.

Chinese Nuclear Tests

On 16 October 1959, China established its nuclear test site at Lop Nur with Soviet assistance. Lop Nur is in the northwest region of the country. China conducted its first nuclear test exactly 5 years later, on 16 October 1964. A uranium device with a yield of 22 kt., codenamed “596”, was detonated atop a 330-foot tower. China was also the first country to declare a “no first use” policy.

It was suspected that the nuclear program likely benefited from Klaus Fuchs, just released from prison, who passed his rudimentary knowledge to Qian Sangiang, head of China’s nuclear program, when they met in 1959.

Beginning in 1960, Chinese scientists also began work on thermonuclear designs. China tested its first thermonuclear weapon on June 17, 1967, which had a yield of 3.3 megatons, 15 years after the first US thermonuclear test.

China began work on ballistic missile technology in 1955 and were able to apply that work to their first nuclear missile which was detonated on October 25, 1966. In total, China conducted 47 nuclear tests, all at their Lop Nur test site, with the last test on July 29, 1996.

The BREN Tower

One of the most important issues of the nuclear age concerns the effect of ionizing radiation on man. Immediately after the cessation of fighting in Japan in World War II, studies were begun that were aimed at learning as much as possible about the immediate and long-term effects of radiation on the survivors of the Hiroshima and Nagasaki bombings. Although the medical studies commenced within months of the bombings, it was ten years before technology reached the stage that it appeared possible to determine, with any real reliability, the radiation dose on those people.

During the Upshot Knothole and Teapot nuclear tests in Nevada, a team of Oak Ridge scientists in cooperation with scientists from the National Weapons Laboratories characterized the neutron gamma radiation from the tests and the effects various types of shielding had on the survivors. The moratorium on weapons testing made it necessary to develop other ways to continue the study.

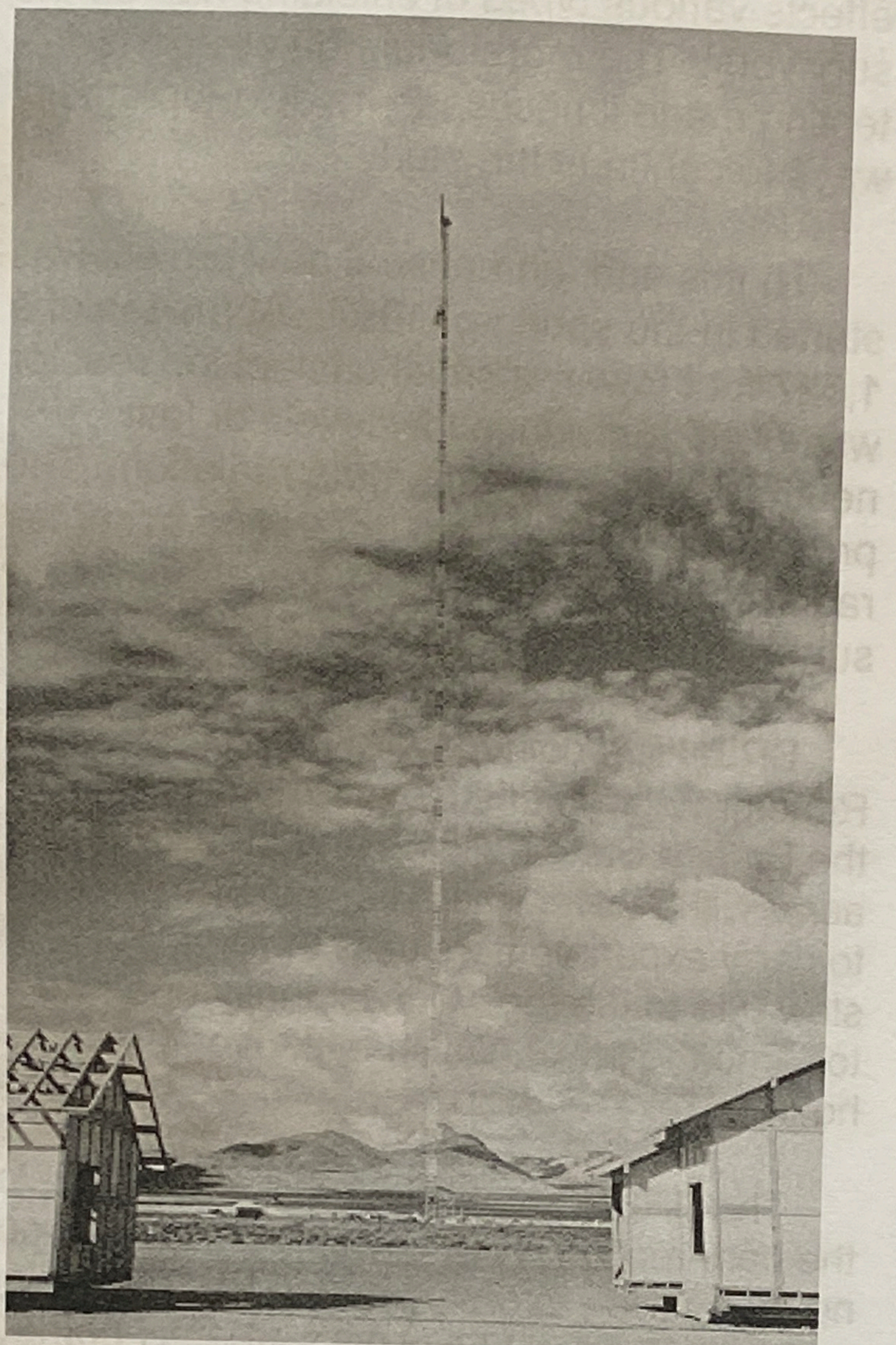
To this end, an unusual new project was started in the spring of 1962. At the top of a 1,527-foot tower, a small unshielded reactor was used to produce low levels of fast neutrons and prompt gamma radiation. The project was designed to determine accurate radiation doses received by the Japanese survivors of the bombings.

BREN is a coined word meaning Bare Reactor Experiment, Nevada. Taller than the Empire State building and only 10 feet across, the tower had a tiny personnel cage to carry experimenters on a thrilling, but slow ride to the top. Occasionally one had to climb the tower, which took over 1 ½ hours.

The BREN Tower could raise or lower the bare reactor, or a specially constructed neutron accelerator. Japanese style houses were constructed below the tower to simulate shielding effects of the structures. The experimental data along with medical information for bomb survivors, determined radiation health effects, and estimated radiation safety levels for workers.

The experiment using the neutron accelerator was the High Energy Neutron Reactions Experiment (HENRE). The neutron accelerator consisted of a Van Ardene proton ion source, power supply, target cooling system, tritium handling system, and other features. The package was mounted on the elevator of the BREN Tower for the experiment. The continuous beam of 14 Mev neutrons from the accelerator sprayed an arc of neutrons up to 2 miles from the top of the tower. Various structures were placed in the beam, including shielded army tanks and other shielded experiments that were instrumented to measure the potential radiation damage to human beings. The HENRE tests were conducted at the

Nevada Test Site in the summer and winter of 1967.



In the foreground of the BREN tower are two structures typical Japanese homes, one without a roof and the other essentially complete.

The tower was used in later years for some non-radiation experiments, including the study of sonic booms. The tower was finally taken down in May 2012.

The Future Off Continent Program

The Limited Test Ban Treaty included several safeguards. One particular safeguard, Safeguard C, addressed the development of a national policy that committed the United States to a "Readiness to Test" capability. Its purpose was to provide a quick-response capability to test nuclear weapons in the atmosphere, somewhere in the Pacific. The Future Off Continent (FOC) Program was a multi-agency responsibility (AEC, DoD, etc.) and included many subprograms such as the aircraft work at Kirtland AFB in New Mexico, the Johnston Island facilities, and the Barking Sands Missile Range at Kauai.

As originally conceived, airdrops were to be decoupled from a fixed site like Christmas Island. Instead, a flying laboratory, consisting of a B-52 bomber, three NC-135 diagnostic aircraft, several RB-57 sampling aircraft, and several support aircraft, would fly to a target area, set up a formation, and conduct the test. Each Laboratory (Sandia, Los Alamos, and Livermore) had the responsibility for the design configuration of its own NC-135. The starting point was an Air Force KC-135 tanker. General Dynamics carried out the modification work at their plant in Fort Worth, Texas. EG&G teams were on-site throughout the mod work, having design responsibilities for camera mounts, tracking systems, and control instrumentation. The modification program started in 1963 and was completed in July 1964. Holmes and Narver built a special compound at Kirtland AFB, in Albuquerque, with a pad for each aircraft and an array of trailers to support aircraft operations.

The 3 NC-135 aircraft on their pads at Kirtland Air Force Base.

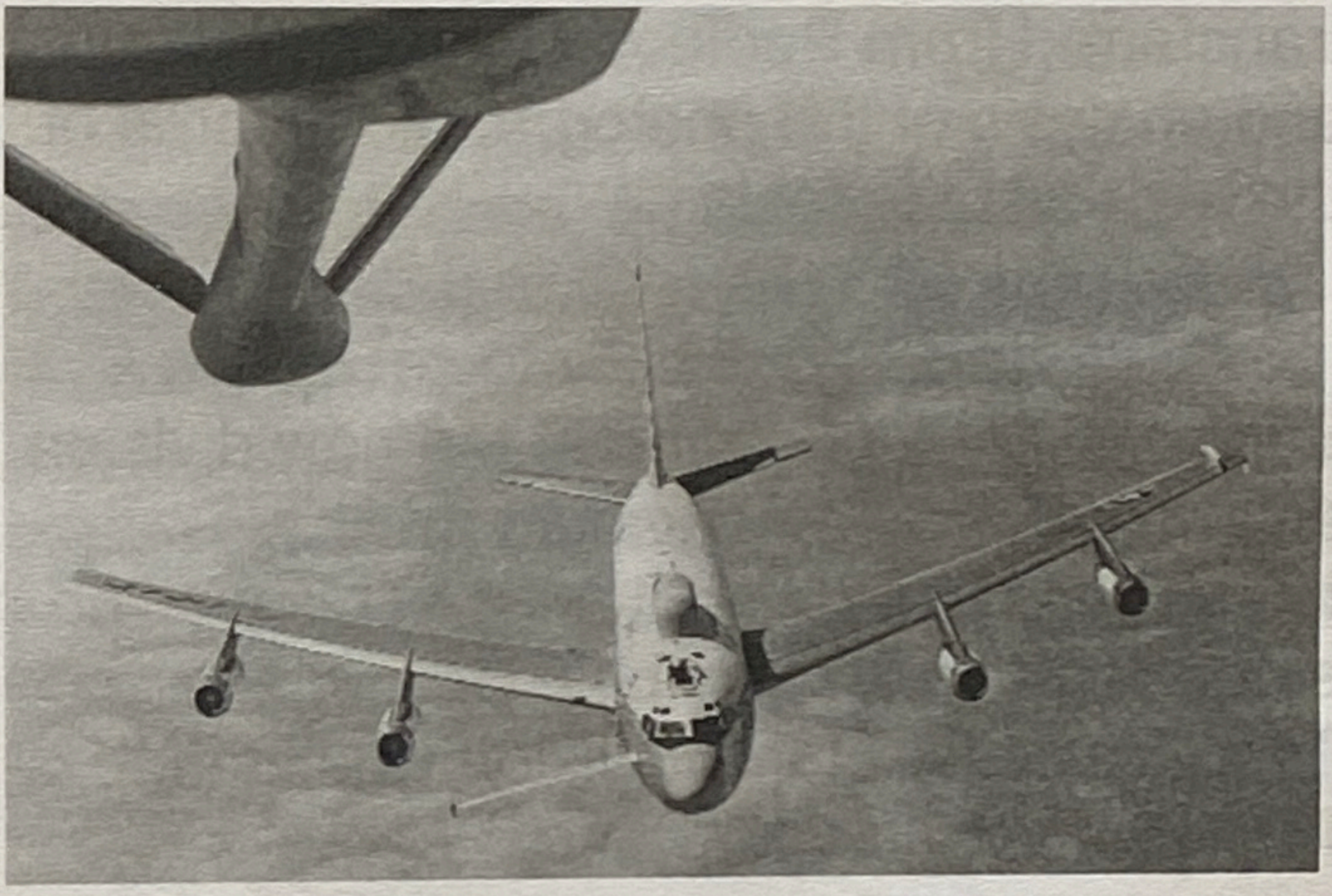
EG&G had operational responsibility for the Kirtland site, and fifteen people transferred to Albuquerque to support the Aircraft Program. This formed the Company's rationale for a presence in New Mexico. In the spring of 1964, an Albuquerque Division was established to provide local administrative and engineering support to EG&G's effort at Kirtland as the trailer park compound was being set up to support the FOC Program.

The resident tenants at the trailer park were principally EG&G and General Dynamics. Scientists from the three laboratories, Los Alamos, Sandia, and Livermore, were on site mainly to support mission preparations. The first field test of this new approach, Operation Crosscheck, was successfully conducted in the Pacific during the fall of 1964.

The Air Force Weapons Laboratory started up operations in Albuquerque in 1963. EG&G's newly established presence nearby gave the company an excellent business opportunity that developed into a long-term relationship with the Laboratory and other Government elements in the area. With time, the Albuquerque Division, of which Kirtland Operations became only a small part, grew to nearly 500 people. A new 72,000 square-foot Albuquerque Facility was completed and occupied in 1968.

Tail number 369, the LASL configured aircraft, taking off from Hickam Air Force Base, Oahu Hawaii during Operation Crosscheck.

1965 saw a broadening of the scope of work for the flying laboratories that were part of the FOC Program. There was a growing concern in the scientific community that if only routine readiness exercises were performed, the technical competence of the crews would deteriorate, and the best people would migrate to more interesting work. To counter this potential deterioration, scientific missions were incorporated into the program. Initially, the scientific missions included the study of natural optical phenomena such as solar eclipses, aurora, and airglow. The first of these missions was a solar eclipse that occurred on May 30, 1965. The path of totality occurred in the South Pacific. The three NC-135s and a NASA chartered Convair 990 were based out of Pago Pago, Samoa. Also participating in the mission was an Air Force Cambridge Radiation Laboratory (AFCRL) aircraft and another NASA plane based out of the Hawaiian Islands. A second eclipse mission occurred over the Aegean Sea south of Athens in May of 1966, and a third Solar Eclipse mission occurred in November 1966 with the path of totality passing through South America.



The NC135's were midair refuelable for extended missions.

EG&G also participated in one earlier solar eclipse mission which was flown using the AFCRL aircraft on July 30, 1963. XR film developed by EG&G for nuclear test photography produced spectacular eclipse photographs. The film has three times the dynamic range of ordinary film and can record intensely bright objects and faint objects in a single exposure, perfect for eclipses and bombs. Using the XR film technology, special films were also developed for use on the Lunar Landing under a NASA contract.

The study of other natural optical phenomena also continued. In 1967, a conjugate aurora mission was flown by two of the NC-135s to study auroral and cosmic ray phenomena simultaneously in northern and southern Polar Regions. Most of the staffing for this mission came from the EG&G Albuquerque and Bedford Divisions.

In late 1967, EG&G opened an office in Los Alamos with 3 employees. The purpose of the new venture was to better coordinate the company's support of LASL programs and to broaden the base of support by making EG&G's overall resources more accessible to LASL technical projects. Staffing increased to 20 people over the next two years.

In 1971, technical activities that previously were carried out in Bedford, Massachusetts at EG&G's corporate headquarters were relocated there, and staffing grew to 120 people, becoming a division. One of the major activities transferred from Bedford was the digitization and analysis of the photographic records of the high-altitude tests.

I had the responsibility to set up the Engineering Department at the new division and convinced 14 engineers and technicians to move out west. This was no small decision for true blue Bostonians. The remainder of the Division was staffed from Las Vegas and Santa Barbara.

The new Division also supported LASL's increased interest in using the NC-135 aircraft in a new class of scientific missions. These new missions included experiments dealing with artificially induced atmospheric optical sources such as rocket-borne plasma accelerators and explosively released barium compounds.

In mid-1971, Harold Agnew, Director of LASL proposed the transfer of the functions and employees of the EG&G Los Alamos Division to the Laboratory. The proposal was formally submitted to the AEC through General Giller, the AGM for Military Applications. The basis for the proposal was cost savings. Approximately 125 EG&G employees and corresponding funding would have been transferred and the office closed. A great public debate ensued which lasted for three months. In the end, 29 people that had been working "behind the fence" for Groups within J Division did make the transfer. This work included the J-8 Laser program and the J-12 Pinex systems. At that point the subject was dropped, but there was some reluctance on EG&G's part for future "behind the fence" work.

Between 1970 and 1972, the operation consolidated activities into an abandoned elementary school, Canyon School. Over a period of seventeen years, modifications were made to meet DOE standards, but a satisfactory solution was never achieved due to the constraints of the Economy Act. As a result of these constraints and an "unsafe" rating from the DOE, EG&G was able to obtain a built-to-suit, corporate leased building in Los Alamos that was occupied in March 1987.

The readiness program ended in 1975 with the loss of Air Force support and the deletion of the word "promptly" from the Safeguard statement by President Ford. At this time, EG&G Kirtland Operations was down to a core of 44 people. With Sandia acting as a white knight, EG&G was able to redeploy the staff to support in-house Sandia projects, which grew over the years to support almost 300 people. Eventually the trailer park on Kirtland AFB was upgraded with portable buildings but was still affectionately known as "Shanty Town" by its residents.

Corporate Changes

In 1964, the new Corporate Headquarters was constructed in Bedford, Massachusetts. The initial three buildings comprised 165,000 square feet. All the downtown Boston activities were relocated to Bedford with the exception of the production of flashtubes and thyratrons, which were moved to an expanded Salem Facility. Santa Barbara Operations (SBO) had completed construction on a new facility in nearby Goleta a few months earlier. A year later, an underground laboratory was constructed on the same Goleta site to house a microwave linear accelerator. The accelerator was designed and built by the Applied Radiation Corporation and funded by the AEC. The high-energy, short pulse machine was used for studies of radiation damage, shielding, dosimetry, detector design, and diagnostic systems. Later, the Linac was modified to reduce its pulse length to 50 picoseconds, producing what was believed to be the shortest radiation pulse generated by an accelerator at that time.

The facilities situation also improved for the Las Vegas Operations (LVO) in 1964. The in-town locations were vacated for a specially built engineering building at 680 East Sunset Road. The three building Escondido complex, a mile east on Sunset Road, was added in 1967. EG&G also occupied the Straza Building and Tansul Building off Sunset Road. The personnel level at LVO surged in 1962 with the resumption of testing to peak strength of 1,594 in 1967, and then declined to a low of approximately 670 in 1973. The large drop in the staffing levels was attributed to the shutdown of the Rover/NERVA project and a significant slowdown in the NTS test program.

Doc Edgerton continued to pursue his interest in underwater seismic mapping. He developed a modified pinger called a Mud Penetrator, first used on the Mississippi to locate concrete flood control blocks buried under five feet of mud. Later testing in the Boston harbor could locate the tunnels under forty feet of mud. One of the objectives was to team up with Jacques Cousteau to search for archeological relics in the mud of the Mediterranean Sea. The approach was highly successful. A few years later, EG&G conducted 160 miles of seismic mapping of the English Channel in preparation for the underwater tunnel connecting England and France. EG&G also outfitted the bathyscaph, Trieste, with cameras and sonar. Trieste made a record 35,800-foot dive into the Challenger Deep.

In 1963, the Trieste located, photographed, and retrieved parts from the nuclear-powered submarine, Thresher, which went down some 270 miles east of Boston. The Thresher accident site was also monitored with an EG&G airborne system to determine if the oil slick was radioactive.

CER

During the Plowshare Program, in 1965, Continental Oil Company, EG&G, and REECo, announced the formation of a new company, CER Geonuclear Corporation, for the commercial application of nuclear explosives. The three companies were already involved in previous government Plowshare Program activities and felt that a separate entity was needed to take up where the responsibilities of the AEC and other government agencies left off. Herb Grier was named president of the new company. CER had established that, for planning purposes, a potential user can figure on a cost of $2 million for a 2-kiloton device. The tentative charge would cover arming and firing services as well as the explosion itself, but did not include site preparation, emplacement, or transportation.

The first commercial application of nuclear explosions for gas stimulation was Project Gasbuggy, fired in December of 1967 near Farmington, New Mexico. EG&G built a refrigeration system that maintained the nuclear device at a constant and appropriate temperature in the elevated underground thermal environment.

A second event, Rulison, was fired in Grand Valley, Colorado, September of 1969. The final event of the series was Rio Blanco, three devices detonated simultaneously in the same hole. The Rio Blanco event occurred in May of 1973 in Rifle, Colorado. CER Geonuclear Corporation was hopeful that this form of gas stimulation would become a standard accepted practice within a few years. In addition to gas, oil from oil shale and copper from chemical leaching were also considered for recovery from nuclear fracturing. Unfortunately, trace radioactivity in the product and the cost of production became insurmountable obstacles for the commercial market.

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The Rulisun device is being brought to a vertical position for insertion during a CER supported event.

After the 1965 annual meeting, the company acceded to Doc Edgerton's long-standing request that he be relieved of the duties of Chairman to devote more of his time to the company's efforts in his main interests of oceanography and stroboscopic photography. Edgerton continued as a director. To fill the vacancy, Kenneth Germeshausen was elevated to Chairman of the Board and Director of Research, and Barney O'Keefe was elected President.

In July 1965, EG&G was listed on the New York Stock Exchange with the ticker symbol "EGG." The following year, stockholders voted to adopt EG&G, Inc. as the official company name, dropping the Edgerton, Germeshausen & Grier, Inc. name. Several months later, the familiar oval logo was dropped, and a new EG&G trademark was adopted and used for many years.

The Underground Test Program

After Operation Dominic, testing was confined to the continental US, mostly at the NTS.

Typical Ground Zero and trailer park for an event with modest diagnostics

An experiment that came into its own after testing at NTS resumed after the moratorium, was PINEX (PINhole EXperiment). Originally, the experiment was basically a pinhole camera taking a time-integrated picture of the 14-Mev neutrons recorded on a zirconium plate. Later, photographic film and filters replaced the zirconium. First used in the early fifties, not much was done with the data due to the lack of computers to do any useful computations. In the sixties, with only underground testing taking place, PINEX began to see more applications. In an underground test, the film pack was recovered through a mud filled tube after the event, hence the name MUDEX. The film pack consisted of a variety of films and filters.

EG&G became involved with the experiment, performing data reduction on the film pack. In the seventies, an electronic PINEX was developed and fielded by LASL and EG&G using a TV camera to record the converted image on a fluor from the pinhole camera and transmitting the image up-hole before the shock wave reached and destroyed the electronics. The next generation used image converter shutters to achieve time-resolved images. By the eighties, both laboratories had incorporated exotic time resolved PINEX systems designed, fabricated, and fielded by EG&G on many of their events.

In the early sixties, LRL had EG&G fielded an underground hydrodynamic yield measurement called "Slifer." A tuned circuit consisting of an oscillator and a shorted transmission line that ran down a pilot hole to the device made up the sensing element. The change in oscillator frequency as the transmission line was crushed was recorded and used to determine yield. Both weapons laboratories used this technique in the years that followed.

A view of an instrumentation alcove on the DoD event, Tomme/Midnight Zepher executed in 1983. EG&Ger Bob Wilkendorf in foreground.

There were basically two types of nuclear tests, those related to the device or weapon itself and those related to the effects of the weapon. This second class of tests was the under purview of the DoD. Generally, they involved a major construction effort, and were carried out in the tunnel complex. One exception was Heron King, which used a vertical shaft with the experiment package on top, dragged off after the detonation and before cratering.

The Labs provided a device with well-defined performance characteristics and EG&G provided its usual diagnostics and T&F support. EG&G also supported Sandia with a wide array of instrumentation support to record sensor and transducer output on objects under test.

In June 1962, EG&G supported the Livermore branch of Sandia Corporation for the DoD effects test, Marshmallow, a tunnel event that involved building the largest vacuum chamber ever used on an event. In the next year, the DoD formed the Defense Atomic Support Agency (DASA) to take on instrumentation responsibilities at the NTS.

In 1965, a long-range $15 million construction project opened Paiute Mesa for expanded testing in the northwest section of the NTS. The new area broadened the nation's nuclear weapons test capabilities for higher yield tests. The acceptable maximum yield for the existing Yucca Flat test area was 300 KT. Paiute Mesa, 27 miles from Yucca Flat, was suitable for higher yield tests at depths of 4500 feet or more.

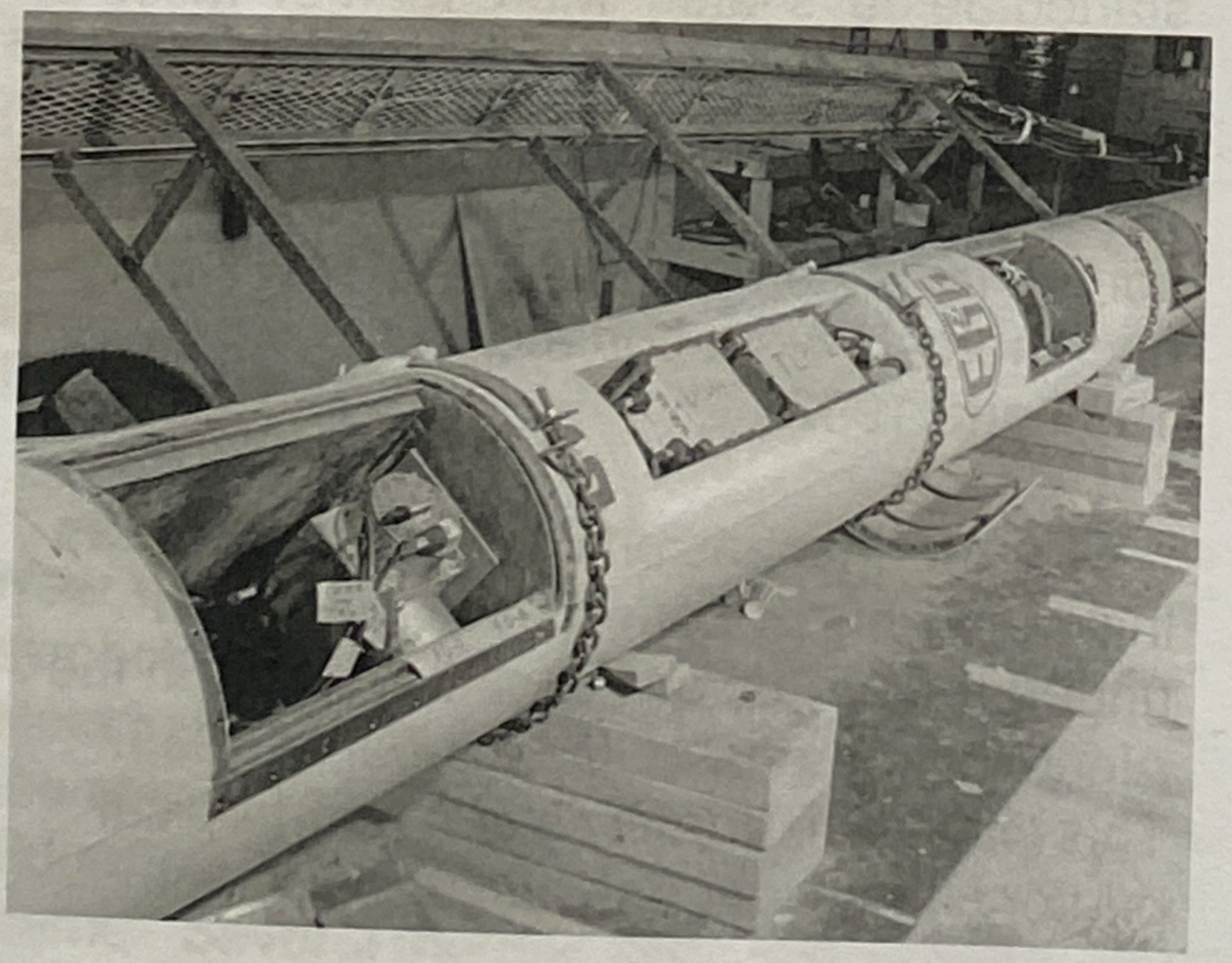
The 166 square mile area on Paiute Mesa was incorporated into NTS in December 1963, and construction crews started 30 days later. More than 50 miles of new roads were carved and blasted across the rugged escarpments, and an airstrip with DC-3 capability was laid out next to the control point compound. A total of 85 nuclear tests were conducted there between 1965 and 1992.

Further expansion of new testing areas included Project Long Shot, a low-yield underground test on Amchitka Island in the Aleutians, detonated in October of 1965. This was the company's first non-tropical off-continent weapons test assignment.

Also in 1965, the NTS saw further testing on Rover-NERVA with the successful testing of the NERVA rocket engine at its full designed thrust of 55,000 pounds. A future NERVA engine, purported to have a designed thrust capability of 250,000 pounds, was never tested.

Further specialization of support to LRL occurred with the opening of an office close to the Lab in 1965. The original shop was set up in Dublin, California, with 12 transferees from LVO. Originally, the scope of work was primarily mechanical engineering related to diagnostic canisters which housed the instrumentation used to measure the performance and physics of underground nuclear tests, then expanded to instrumentation design and applied sciences. The operation was relocated to San Ramon in 1967, constructing a new 23,000 square foot building on a site that already contained a 7,000 square foot building.

A major instrumentation project at the time was NADS (Nevada Automatic Diagnostics System), involving integrated data acquisition, microwave transmission, and data processing functions for a nuclear test. In 1970, driven by changing design requirements of the two weapons labs, the LRL CRT operation, originally part of the Bedford CRT Operations, was also moved to San Ramon so the laboratory could have greater oversight of the development of future designs.



ITS canister in final assembly at the Escondido Facility.

In 1968, EG&G proposed to LRL a new concept of operations designed to conduct relatively low yield and simple diagnostic nuclear tests at a much lower cost. This concept was adopted and named the Integrated Test System (ITS). During the 1968 – 1970 period, ITS allowed the conduct of many low-yield nuclear parametric studies that resulted in the rapid development of a new and advanced generation of nuclear primaries.

Two alternative sites to the NTS were under study for high-yield nuclear testing, Amchitka Island in the Aleutians, and Hot Creek Valley in Central Nevada. EG&G sent crews to the Central Nevada site, known as the AEC's Supplemental Test Site (STS), to install timing and firing, photographic, seismic, and other instrumentation for the seismic calibration shot, Faultless, detonated in January 1968.

A seismic calibration shot, called Milrow, was also detonated at Amchitka in October 1969 in anticipation of the Cannikin event, the proof test of the Spartan warhead. Milrow had a yield of about 1-megaton.

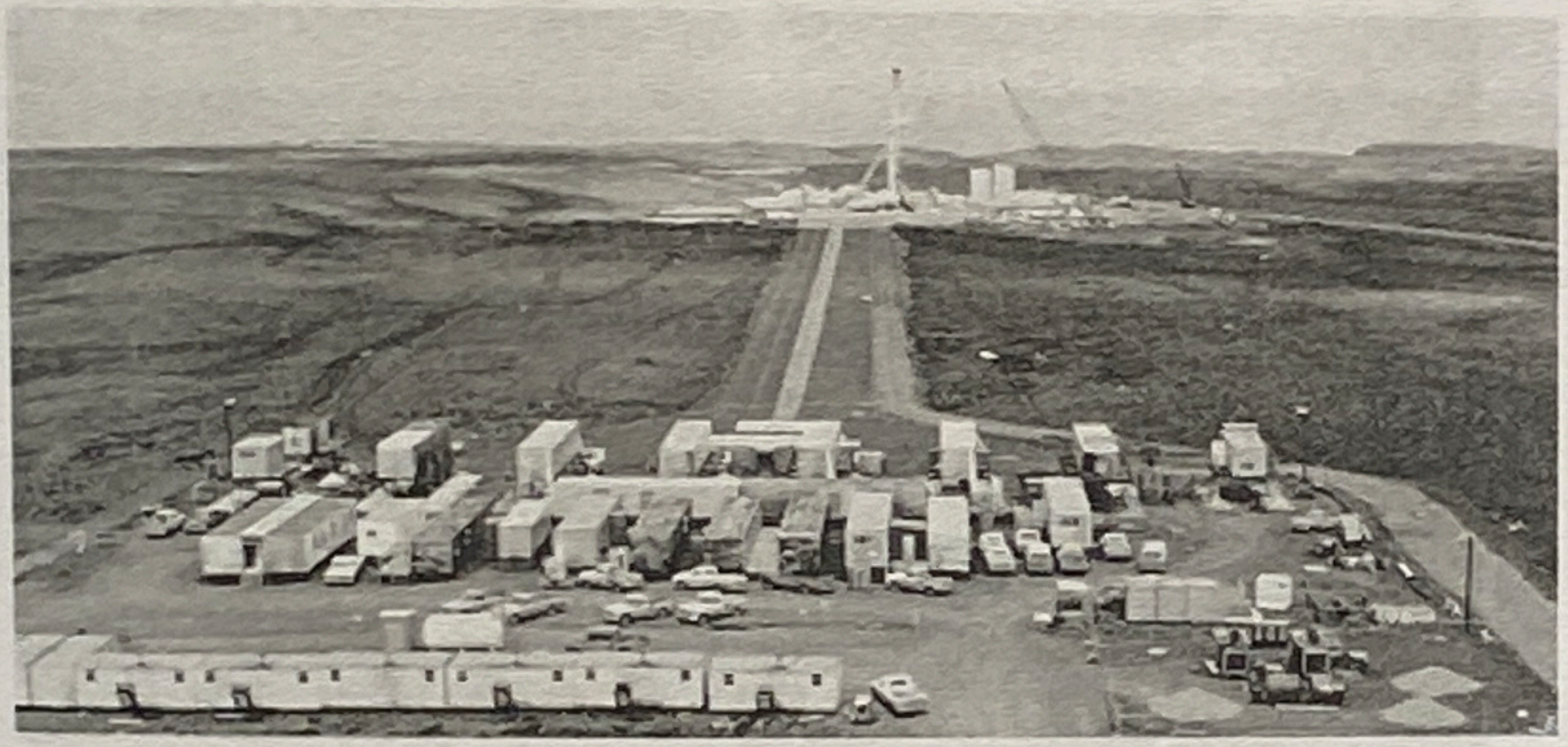
The Rover Program ended abruptly in early 1969, just at the beginning of the Nixon administration. Funding was zeroed out and there was a mad scramble to relocate as many people as possible, but there were still a considerable number of layoffs. This was the time the space shuttle was being built and was suffering from overruns. The shuttle program was NASA's highest priority and Rover was a long-range project. NASA made the decision to devote all available effort to the shuttle program. It was four more years before EG&G was completely phased out of the program.

On December 18, 1970, the event Baneberry was detonated. There was a significant failure of the containment system, which resulted in venting of a substantial amount of nuclear debris that traveled well off the NTS. Testing was stopped for six months while containment techniques were re-evaluated.

Before 1971, the Berkeley and Livermore laboratories were conjointly known as the Lawrence laboratories. When

Roger Batzel was named director in 1971, replacing Michael May, LRL became an independent laboratory and changed its name to Lawrence Livermore Laboratory (LLL). Completing the laboratory name change story, in 1980 all three weapons labs added "National" to their names, hence, Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), and Sandia National Laboratories (SNL).

In 1975, the AEC was reorganized and renamed the Energy Research and Development Administration (ERDA). Two years later, ERDA became the Department of Energy (DOE).

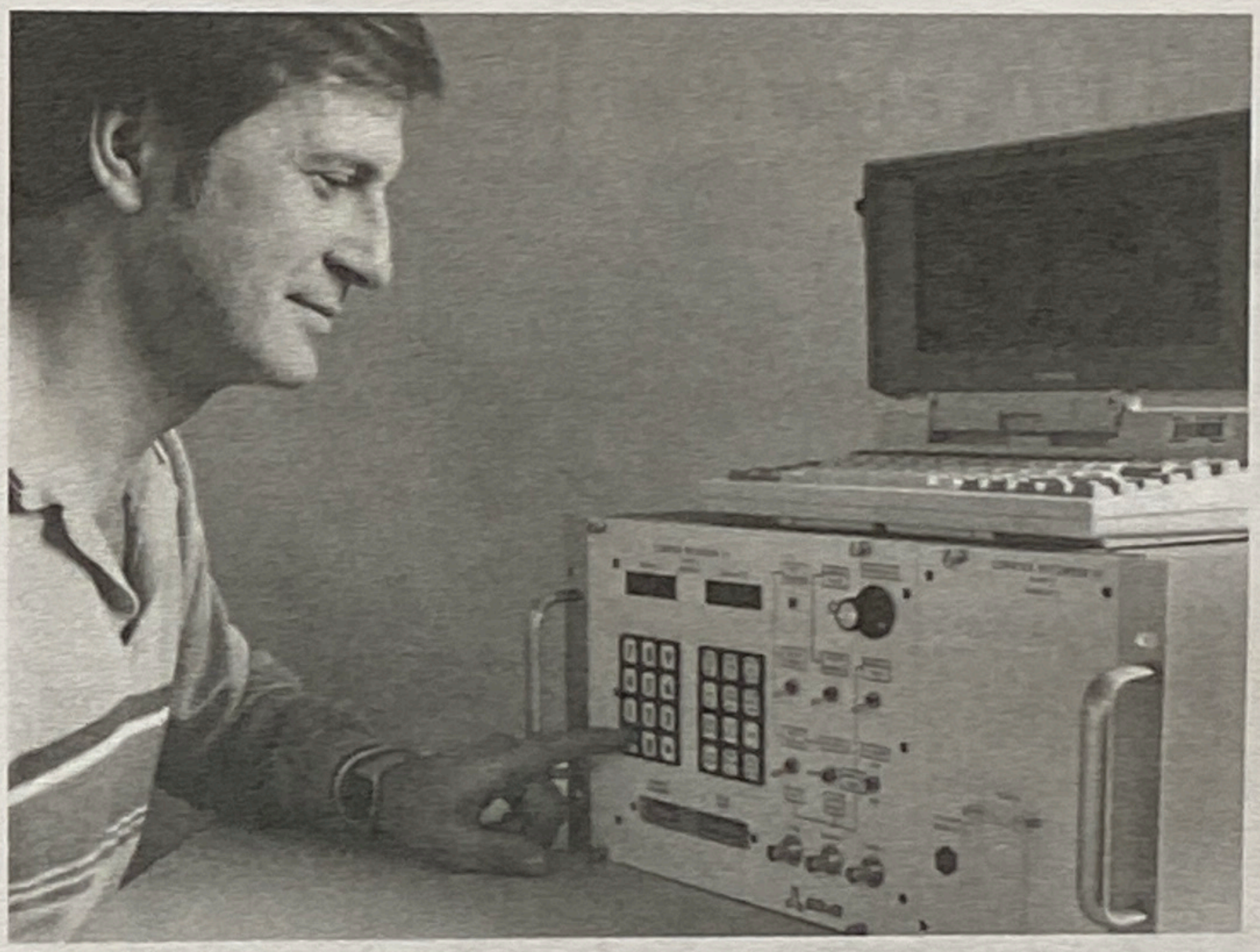


View of the recording trailer park and ground zero at Amchitka for the Cannikin Event

In November 1971, the biggest underground anti-ballistic weapons test ever attempted (nearly 5 MT) was detonated more than a mile beneath the surface of Amchitka Island. The purpose of the test, an LLL event code named "Cannikin," was to verify the design of a new warhead for the Spartan missile. For the test, more than twenty trailers, 33 HVAC units, six transportainers of equipment, plus a 107-ton EG&G built diagnostic canister were trucked to Seattle and trans-shipped to Amchitka by barge.

CORRTEX

In the early seventies, searching for a more passive method to measure hydrodynamic yield on an underground event, LASL worked on a new experiment, CORRTEX, (COntinuous Reflectometry for Radius versus Time EXperiments). A coaxial cable is run down hole to the device under test, either in the emplacement hole or a satellite hole, and is attached to an EG&G designed electronics unit that generates a train of pulses and looks at the reflected signals. As the shock wave crushes or shortens the cable, the reflected signals are recorded and the rate the shock wave travels is calculated. Since there were no active elements involved in the sensor, just a bare coaxial cable, the system was tested and proposed for verification measurements for two closely linked nuclear test agreements, the Threshold Test Ban Treaty (TTBT) and the Peaceful Nuclear Explosions Treaty (PNET).



EG&G engineer Larry Pirkl programs a command into the CORRTEX system.

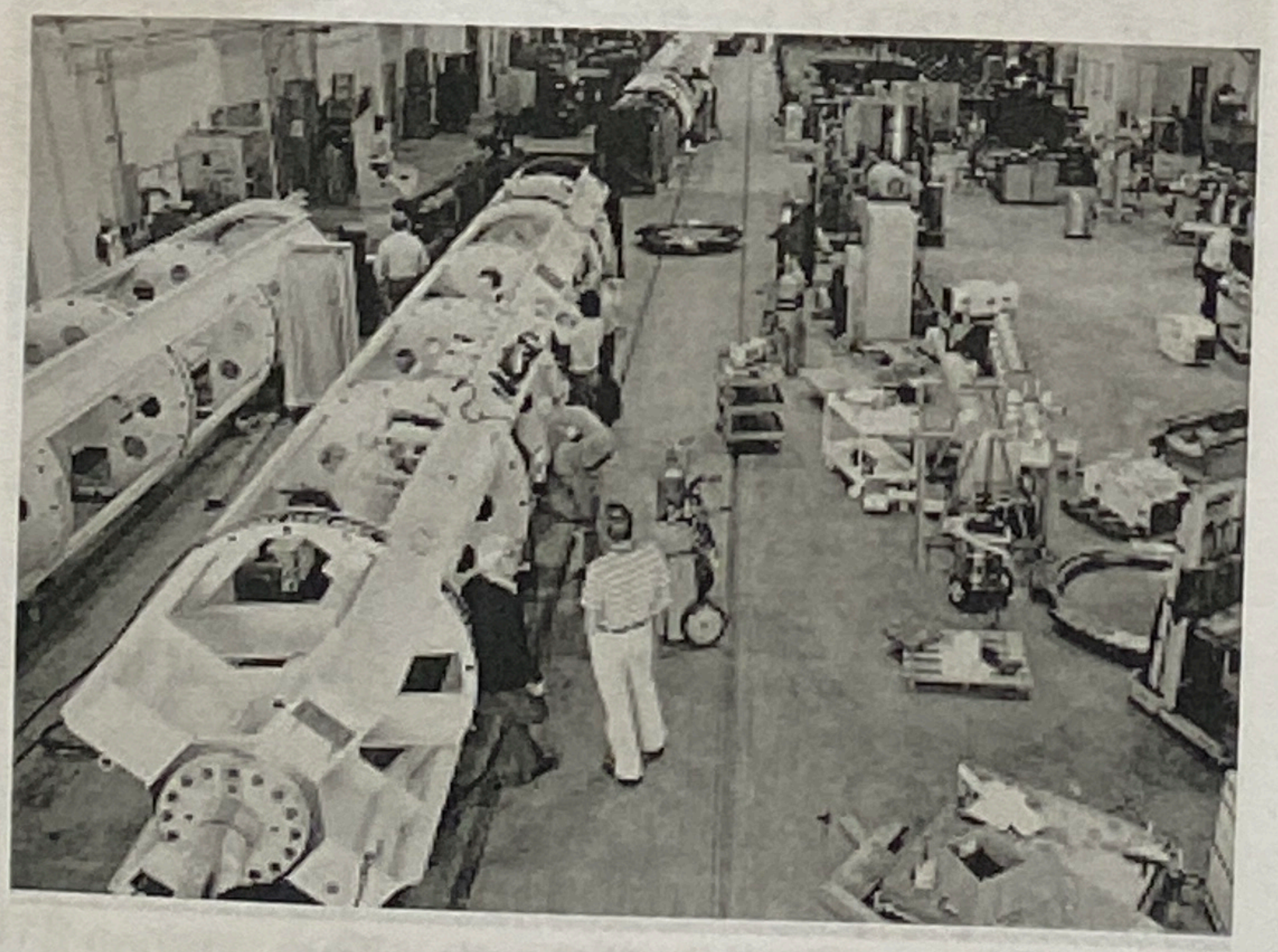
In 1986, President Reagan proposed using CORRTEX for the150 kt yield verification to the Soviets. In 1987, EG&G built 23 new CORRTEX units, some were given to the Soviets for their inspection. The CORRTEX unit became the yield verification measurement used for the Joint Verification Experiments (JVE) held at the NTS and Semipalatinsk, Russia.

EG&G had over 50 people involved in the CORRTEX JVE experiments. Representatives from NVOO and 20 EG&G technical people traveled to the Russian Test Site near Semipalatinsk. Two complete yield verification systems containing 12 CORRTEX recorders were used in the experiment.

EG&G tech Michael O'Connor has just given flowers to some young girls and is resting on the steps in front of a Semipalatinsk co-op market.

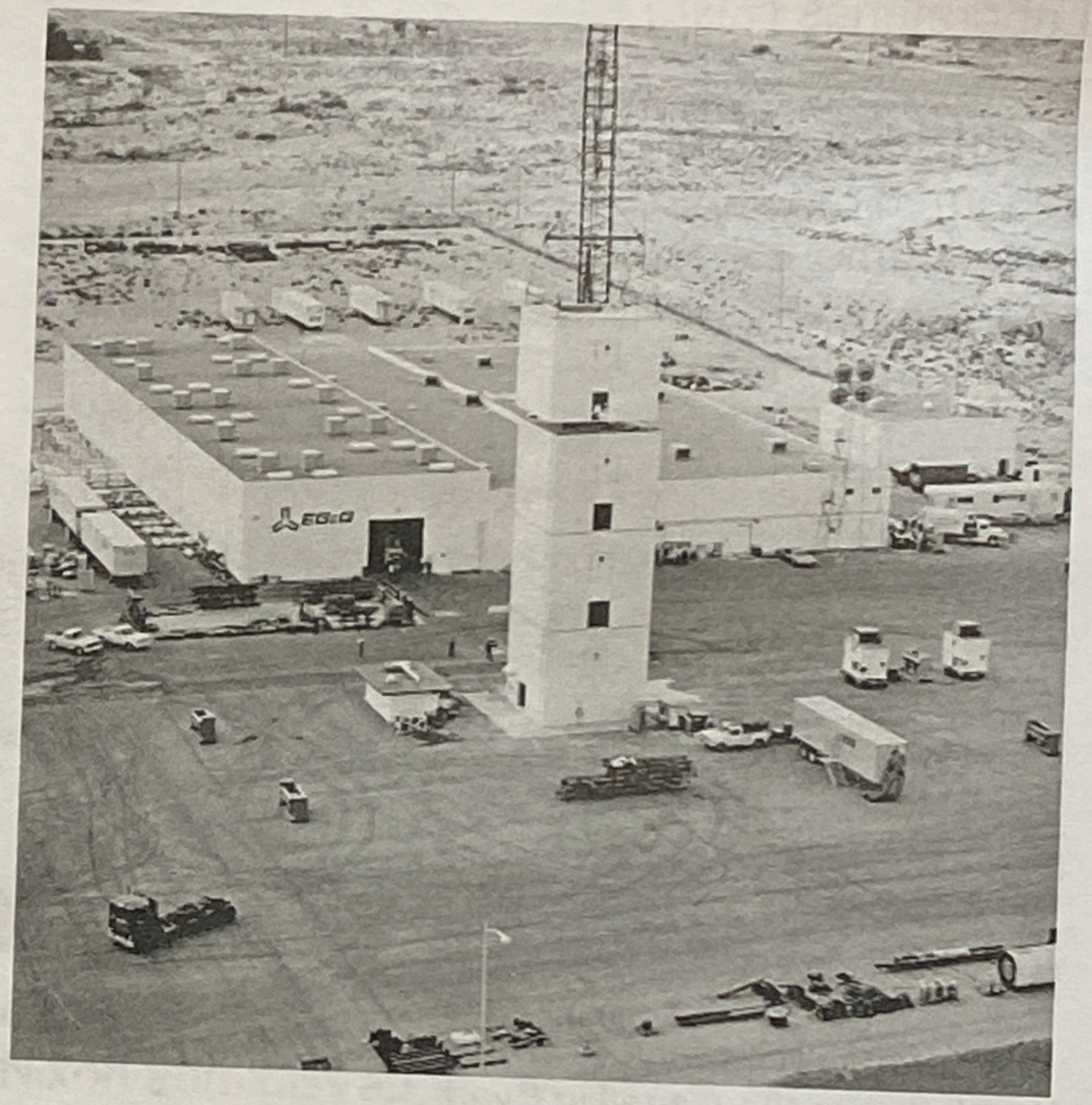
North Las Vegas

In 1976, a new North Las Vegas Facility was custom built to support diagnostic canister construction and electronic systems assembly and checkout for the LLL Program. An activity originally carried out at the Escondido Complex. The Escondido Complex was then modified for occupancy by the Aerial Measurement Operations. The North Las Vegas Facility was designed to implement the Augmented Test Logistic Assembly System, (ATLAS). First proposed by EG&G to LLL in 1971 as a methodology by which very complex nuclear events could be executed in a far more cost effective and safe fashion, it took 5 years to finally implement the process.



Canister assembly in the new NLV Facility.

The system was designed to allow complete fabrication and testing of the instrumentation canisters used to determine the results of a nuclear test. REECo drilled a hole large enough to handle LLL canisters and an NTS modular tower was erected over the hole. Tracks ran from the hole the short distance to the facility where the canisters were fabricated. The canister was assembled and erected in the tower allowing for final alignment and testing in North Las Vegas, reducing the more expensive and time-consuming field time.



Assembling the NTS tower in its original position at the ATLAS Facility.

The building also had an underground source range with limited access. The source range contained two large radiation sources. The largest was a 25,000-curie Cobalt 60 source, purchased from the Oak Ridge National Laboratory and installed in 1977. The second large source, a 1000-curie Cobalt source, was purchased in 1963 and relocated from the Escondido complex to its new home in North Las Vegas.

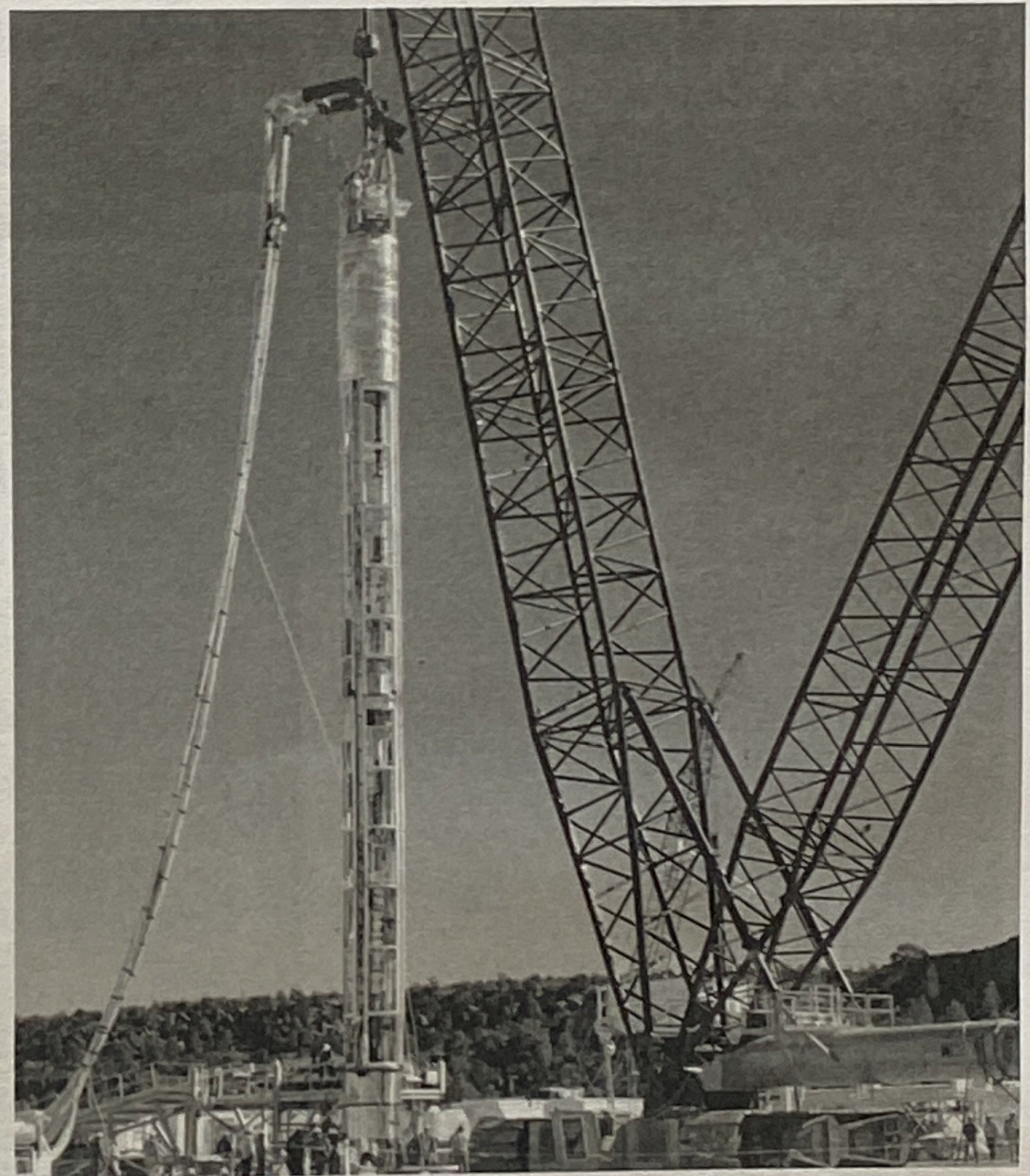
In later years, a second hole was drilled at the back end of the facility and the tower was relocated there to make room for a major construction project consisting of a permanent twin tower structure and a connection to the high bay. The twin tower could handle two canisters simultaneously to support a planned enhanced test program, but the program never reached that anticipated level of activity. With this facility, all subsequent LLL event test systems were pre-assembled and checked out prior to shipment to the NTS, thus reducing NTS residency time, logistics, and operational costs.

On the other hand, LASL's approach was totally different. The experimental packages, which they call racks, were constructed in their own shops at Los Alamos. EG&G personnel would travel to Los Alamos to fit detectors and other components. The rack would then be trucked to the Test Site and be emplaced in the tower over the event hole for final alignment and shielding. Just one of the many differences in the way each Lab approached their testing program.

1977 also heralded the use of fiber optics at the NTS, first employed by LASL. The experiment was a Fiber Optics Alpha Measurement (FOAM), where the fiber was both the detector and the transmission line. The bare fiber end was exposed to gamma radiation, producing Cherenkov light that was sensed up-hole on an EG&G designed detector. Driven by the demand of ultra-high frequency requirements, EG&G pioneered the development of welders, splicers, and connectors needed for field applications. As the industry matured, this support equipment was further developed and provided by commercial vendors. The optical fibers were able to provide much higher frequency signal transmission at a fraction of the cost of copper coaxial cables. The LEDOUX event in 1990 had the most extensive application of fiber optics with 480 downhole fibers used for signal transmission.

The ATLAS facility in North Las Vegas, on Losee Road, turned out to be the seed for the North Las Vegas (NLV) complex. In 1978, an attempt was made to add a 154,000 square foot facility abutting the ATLAS facility property. The impetus was to provide a prestaging area for LASL/NTS trailers and an expanded engineering space for the LASL Program. Five bidders responded, but the RFP was withdrawn. At the time, the DOE had arcane rules for real estate that made adding space very difficult.

As an alternative way to add space, in 1981, EG&G negotiated with Collins Brothers, the builder of the ATLAS facility, to construct a 30,000 square foot warehouse building for lease on an adjacent lot. This building turned out to be the first phase of the B complex. The highly restrictive real estate regulations in the DOE prevented a more systematic approach to adding the needed space, so compromises in design and lease terms were necessary. The ATLAS facility had a purchase clause that was exercised by the DOE. Eventually, the entire 80-acre site came under Federal ownership.

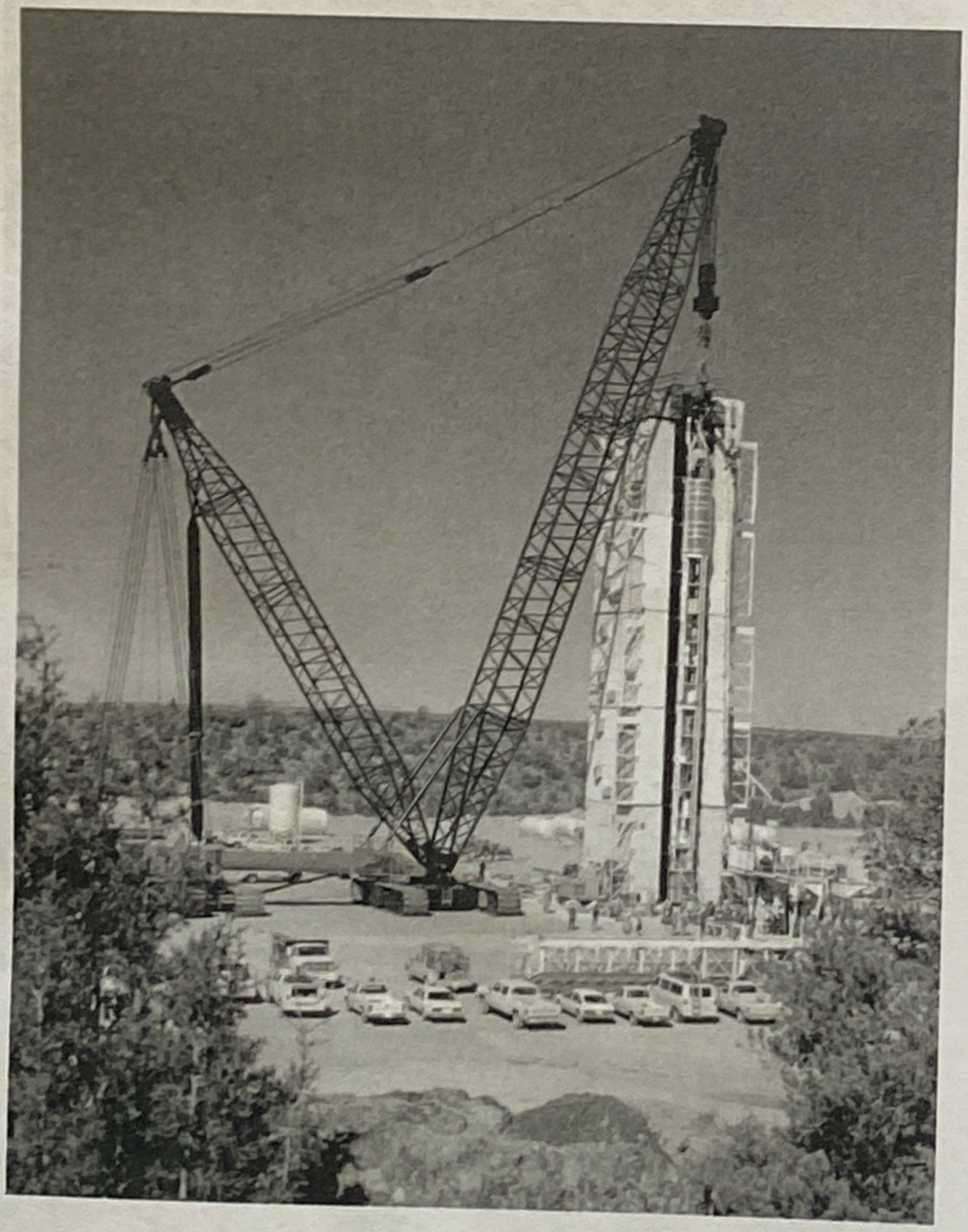


The canister for the Barnwell event, a joint US/UK experiment fired in 1989, readied for placement in the tower over the hole on Paiute Mesa.

In 1985, EG&G relocated its San Ramon office to Pleasanton, California. This was done to accommodate the growth in personnel and to provide upgraded laboratories necessary to the development of advanced photo-optic diagnostic systems demanded by Laboratory physicists. Keith Heinrichs, an EG&G scientist, developed an advanced streak tube with fast sweeps and enhanced resolution over available commercial units.

EG&G engineers designed the supporting camera electronics, and the streak camera became another standard diagnostic recording tool for subsequent nuclear testing. In later years these cameras became one of the standard recording devices for current sub-critical tests at the NTS.

During the 1960's, when testing resumed, NTS was very active, conducting over 40 tests per year with a peak of 72 tests in 1968. In the 1970's, it was generally more than 20 tests per year, dropping down to the high teens in the 1980's, and half that in the 1990's. Eight tests were conducted in 1992, the final year of testing.



Placing the Barnwell canister in the modular tower for final preparation prior to insertion.

The largest yield underground nuclear test at NTS was the Boxcar event detonated in April 1968, with a yield of 1.3 Megatons. It was doubtful if that yield could even be matched in future tests due to the enormous public furor raised over integrity of the nearby Hoover Dam when exposed to the seismic shock of such a large explosion. There was also concern about damage to high-rise buildings in Las Vegas. When the US needed to test a 5-megaton device it was fired as the Cannikin event in 1971, approximately a mile underground on Amchitka Island in the Alaska Aleutian Islands chain.

In all, the US conducted a total of 1054 nuclear tests, 24 of which were joint US/UK tests. One hundred and six tests in the Pacific, 3 tests over the South Atlantic Ocean, 928 at the NTS, and 17 at other continental locations. There were 839 underground events and 210 atmospheric events including high altitude, 12 of which were rocket borne. Five events were underwater.

The US also fired a total of 25 balloon shots, 24 at the NTS and one in the Pacific. The one Pacific event, Yucca, was a 1.7 kt event fired at an altitude of 86,000 feet in the vicinity of Enewetak. President Kennedy prohibited future balloon shots when testing resumed in 1962.

Worldwide there were over 2100 nuclear tests, with a cumulative total yield of over 540 megatons. About half of the tests were conducted by the US. The Soviets come in second with 727 tests, some with multiple devices. However, the sum total of yield was much higher than that of the US program. France comes in third with 217 tests, and rounding out the top four, the UK conducted 88 tests. North Korea is the only country still with an active test program.

Corporate and Contract Changes

In July 1971, the Western Division of EG&G became the AEC Contract Group and was reorganized along programmatic, as opposed to functional, lines. The major subordinate elements within the group became the LLL Program, the LASL Program, Sandia Program, NVOO Program and Administration. Offices that had been established in San Ramon, California, to support LLL, and Los Alamos, New Mexico, to support LASL, became part of the appropriate programmatic organization. Portions of the Las Vegas Operation population and facilities were also assigned to each Program. The Contract Group kept one East Coast connection, the CRT Operations in Bedford, Massachusetts, an element of the LASL Program. The Sandia Program had operations in Las Vegas and Kirtland AFB.

Gaelen Felt designed a unique cost model that normalized programmatic costs across locations so the laboratories would not discriminate between sites on a cost basis. Felt, a scientist to the end, explained and described the new cost model to the AEC using partial differential equations. The accountants in the audience just rolled their eyes. The model, however, was widely used with only slight modifications until the end of the contract in 1995.

Also in the early 1970s, the AEC started actions to capture the work performed on weapons test activities under a separate contract arrangement. The Las Vegas Operations was primarily devoted to AEC work with the exception of a significant group of DoD contracts. The manager of that work, Bill Barrett, proposed and succeeded in having the work split off as a separate EG&G division, EG&G Special Projects. Forty EG&G employees joined Barrett, who was named General Manager and started operations with contracts valued at just over $1 Million. By the early 1990s, the division's sales exceeded $100 million.

In 1972, the AEC's goal to make the work wholly captive to the government and independent from the rest of EG&G, was achieved. Since some critical work was still being performed in the non-captive part of EG&G, a separate contract was written to the company to cover that effort. The AEC captive element included work done in Las Vegas, NTS, San Ramon, and Los Alamos. A separate contract was issued for the work done for the AEC in Albuquerque, Bedford, and Santa Barbara. Eventually, these locations were also brought under the captive contract. All corporate equipment, including office furniture used at the captive locations, was either removed or purchased by the AEC. After captivity, the name AEC Contract Group, sufficed for several years, though somewhat confusing, until it was renamed EG&G Energy Measurements Group in 1977.

By the end of 1975, there was a serious deterioration of the relationship between the Group's management team and the AEC. As a result, Gaelen Felt and some of his direct reports left the company and Bob Hammon was named General Manager. Hammon had previously managed the LLL Program as Program Manager.

In 1976, EG&G moved their corporate headquarters to Wellesley, Massachusetts, vacating the Bedford Complex. The Bedford CRT Operation was able to remain in place for four more years while the new tenant renovated the property. The Operation then moved to a renovated facility in Woburn, Massachusetts. The Woburn CRT Operation continued operations until the spring of 1994, when work there was discontinued.

J. Y. Cousteau, Parviz Babaai (Cousteau's engineer) and Doc Edgerton aboard the Calypso.

In 1975, Edgerton continued his close collaboration with Jacques Cousteau, this time treasure hunting in the Mediterranean Sea using EG&G's side-scan sonar tow fish. The objective was to locate ancient cities and remnants of sunken ships. Recovered treasures were turned over to the Greek Government.

A few years later, Edgerton brought his side-scan sonar to Scotland's Loch Ness, joining Cousteau in search of the infamous monster. Doc and Cousteau were notable enough scientists to attract the attention of Gary Trudeau who did a series of satirical cartoon strips in Doonesbury on the expedition.

In June of 1978, EG&G was asked to develop contractor support at the DOE Morgantown Energy Research Center. The Station, as it was called, was staffed with about 250 DOE employees doing research in fossil fuel applications. The Station Manager, Augie Pitrolo, desired to have an O&M contractor on site. EG&G built up a cadre of support and ran it as an operation of EG&G Energy Measurements, while building the contractor structure. In 1980, when a bid for the work was released, EG&G won the competition and ran it as an element of EG&G Washington Analytical Services Center (WASC).

Remote Sensing

In addition to atmospheric nuclear testing, the need for a nuclear monitoring program became more apparent after the Windscale accident in Great Britain. On October 10, 1957, a reactor at a nuclear materials production facility spewed out enormous quantities of fissionable material onto the landscape and into the North Sea. It was clear that only an airborne platform would be successful in accurately mapping the fallout pattern.

The Department of Biology and Medicine of the AEC had an aerial radioactivity survey program in progress for several years. The surveys covered US tests and were performed using a DC-3 aircraft. The U. S. Geological Survey (USGS) in partnership with Oak Ridge National Laboratory originally developed the system to prospect for uranium deposits in the western US.; however, the radiation plumes from the NTS disrupted the prospecting activity to the point that the USGS asked to be replaced. They also wanted out of the "bomb business" of tracking clouds.

EG&G was asked to develop a replacement system. The resultant design was the Aerial Radiological Monitoring System (ARMS) which could be carried by a fast, light plane. The design work was carried out in Santa Barbara, and in 1961, the system was successfully tested using an E50 Twin Bonanza Beechcraft. The group was commissioned to perform many surveys throughout the entire country. As the project developed, the aircraft was on 24-hour call to participate in the Radiological Assistance Plan in the event of a nuclear accident. Several years later, the aircraft and operational responsibility was transferred to the Las Vegas Division.

One of the more significant early surveys occurred in November 1963. A massive explosion at the highly classified Medina Facility site occurred near San Antonio, Texas, involving 60 tons of explosives and a large quantity of uranium.

Bill Verheydan and John Schmidt working at the instrument console in the NATS Martin 404.

In 1965, a bigger radiological survey aircraft, a Martin 404, was acquired and extensively modified at Santa Barbara for aerial radiation detection applications. The Martin was instrumented for the Nevada Aerial Tracking System (NATS), to be used as a precautionary safety measure to survey for any possible airborne nuclear debris at the NTS. The system at that time could detect five to ten percent changes from normal background activity.

Two surveys flown in 1968 and 1969 of the West Valley Fuel Processing Plant in New York showed a 30 percent increase in the Cesium 137 being released into the surrounding water shed. The results of the surveys led to the shutdown of the site. Also in 1969, a potentially lethal Cobalt 60 source lost in interstate transport was located and recovered by ARMS before anyone else got close to it.

Instrument array aboard the ARMS aircraft.

After 10 years of operation, the ARMS aircraft had surveyed 60,000 square miles. The Environmental Protection Agency (EPA) used ARMS data to determine the basis for the normal annual dose to the population in the US due to cosmic and background radiation. The ARMS data was critical because it provided an average background reading over very large areas that were co-located with most of the population. (i.e., 170 mRem/year)

Adding to the aircraft's surveying capability, a four-camera multispectral photography system and an infrared scanner with a down-looking window and port were installed. With this change, ARMS was renamed the Aerial Measurement System (AMS). The AMS aircraft started coverage of NASA's Apollo Missions, starting with Apollo 12 in November 1969.

In 1969, a new EG&G Doorway Personnel Monitor was displayed at the AEC's Symposium on Nuclear Safeguards Research and Development held at LASL. Developed at Santa Barbara, the monitor was capable of detecting the presence of fractional-gram quantities of plutonium being carried by an individual walking at normal speed past the monitor. First installed at the Rocky Flats plutonium fabrication plant in Colorado, the system was continually refined and deployed at many critical sites and facilities around the country.

In the early 70's, there was a rash of articles dealing with making and detonating homemade nuclear weapons. The most prominent of these was John McPhee's book "The Curve of Binding Energy." As a result of the attention brought by this book and other articles, the nation saw a rise in nuclear threats. While all the threats up to that time proved to be hoaxes, the nation realized that it was ill prepared to respond to a threat of nuclear terrorism, be it real or hoax.

In early 1972, the Assistant to the Secretary of Defense for Atomic Energy called the chief scientist of EG&G's Santa Barbara Division and said, "Can you be in my office 9:00 am tomorrow?" The chief scientist, Dr. Harold Lamonds, flew to Washington overnight and met with the Assistant Secretary the next morning. The secretary explained that the FBI had word that a self-proclaimed terrorist group called "The Omega Seven" had claimed to have a nuclear weapon and would set it off in New York City if the upcoming Amchitka nuclear test was conducted. He also said that the FBI did not believe the claim was credible but wanted details about what the Nation's capabilities were if it was real. Lamonds supplied information based on EG&G's long-time mission of searching for low level radioactive sources.

Over the next few months, the Santa Barbara Division was awarded contracts from the DoD Defense Nuclear Agency to explore ways to improve the capability to detect nuclear devices. This was followed by the AEC establishing the Surveillance, Accident, Nuclear Detection System (SANDS). NVOO was given management responsibility for SANDS.

A nuclear threat was made to the city of Boston in 1974. NVOO was asked to respond and key personnel from NVOO along with several EG&G personnel were deployed to the Boston area along with nuclear instrumentation to search for the threat. The threat proved to be a hoax and the personnel returned to Nevada without exercising their equipment, but because of this deployment, it was clear that the nation was ill prepared to counter such a threat should it prove real.

Also, shortly after the Boston incident, a Presidential Directive issued by President Ford, made a nuclear threat, real or hoax, a violation of the Atomic Energy Act. It assigned lead responsibility to the Federal Bureau of Investigation, with technical responsibility to the AEC, and some support responsibility to the Department of Defense, primarily to the Explosive Ordnance Disposal (EOD) units.

Following this Presidential Directive, Ernest Graves, head of the military applications for the AEC, assigned the responsibility to NVOO, for the "search and identification of lost and stolen nuclear weapons and special nuclear materials, nuclear bomb threats, and radiation dispersal threats." This assignment was the initiation of the Nuclear Emergency Search Team (NEST). The Team's objective was to provide technical assistance to the FBI in dealing with activities, including terrorist threats, involving the use of special nuclear materials. During the formative years, the effort was focused on developing the capability to search for special nuclear material that may have been lost or stolen. With support of the laboratories, the capabilities expanded to include diagnostics, device assessment, disablement, and containment.

As the number of nuclear threats grew, there was steady, growing sophistication of the operational response for dealing with such threats in a more organized fashion. The budgets grew and EG&G's Aerial Measurements Operation (AMO) developed and produced radiation instrumentation designed to search for nuclear threat devices. There was general agreement at the time that such a search should, if possible, be carried out clandestinely to not alarm the populace. As a result, the first search instruments were built into American Tourister Briefcases. This allowed search personnel to conduct a search quite surreptitiously. Two types of briefcase search systems were designed and built. A gamma system using Sodium Iodide as the detector and a neutron system using Helium 3 as its detector. The leaders of the response force realized that not only was equipment needed but that an emergency response support organization was also required.

The AEC continued to look to NVOO to develop the technical and operational capability that would be needed to deal with a nuclear threat. In addition to EG&G's role in developing and producing nuclear search equipment that could detect the radiation of a nuclear threat device from background, they were also tasked with providing communications for the response community. Work started on developing such systems in the 1975-time frame. Also in 1975, a threat was made against a Union Oil Refinery in the Los Angeles area. This threat was initially deemed credible, and several Federal and EG&G personnel were deployed to the area. The refinery and its surroundings were searched with negative results and the personnel returned to Las Vegas. Subsequently, the FBI, using more conventional methods, discovered and apprehended the perpetrator of the hoax. He went on to become the first person convicted and sentenced to prison for a violation of the Atomic Energy Act.

An adjunct of the Las Vegas-based AMO was set up in the Washington DC area in 1976. Originally, the office was conceived as a temporary operation driven by concerns over the bicentennial celebrations. The Washington Aerial Measurements Operations (WAMO) was staffed with Las Vegas employees taking turns manning the office, but there was enough activity supporting Washington agencies, that permanent staff was put in place by the end of the first year.

Helicopter survey during the TMI incident.

The decision to keep an East Coast operation proved to be fortuitous just a few years later. On April 29, 1979, WAMO was called on to help monitor the area around the Three Mile Island nuclear power plant, which had malfunctioned and was close to a meltdown of its radioactive core. A team was on the scene 2 ½ hours after the call. WAMO monitored the region around the plant with their specially equipped helicopters along with ground surveys and determined that there was no serious environmental contamination. But the world was sobered by the possibility of a nuclear reactor disaster. As a result of the confusion and contradictory information that plagued the Three Mile Island incident, the Federal Radiological Monitoring and Assessment Center (FRMAC) was created to serve as a clearinghouse for data.

In mid-1977 the first major NEST exercise, NEST 77, was conducted. It involved NVOO, EG&G, LLL, LASL, Sandia, and EOD personnel and was conducted at the Idaho National Engineering Laboratory (INEL). The exercise involved the search for, identification of, and the neutralization of an improvised nuclear device (IND). While an operational organization had been created, this was the first time it had been tested. In preparation for this exercise, AMO developed and constructed a small mobile telephone exchange, which was deployed to the exercise site to provide emergency communications for the response force. This exchange was built into a standard, wide-body airline transportainer. It was the precursor to several so called "pods," housing needed operational capabilities that were built into wide body luggage containers. Included were a communications pod, a photo processing pod, a photo printing pod, a data processing pod, and a mechanical pod containing a wide variety of special tools suitable for emergency use.

NEST 77 revealed the complexities of a nuclear emergency response and gave the planners much to consider. A study of the successes and failures of this and other exercises led to continued development of the NEST response. Several working groups were established to study and solve the problems facing the response force in several areas, these included search and identification, diagnostics, disablement, damage limitations, communications, operations, and access. Membership in these working groups consisted of personnel from EG&G, LASL, LLL, Sandia, NVOO, EOD, and FBI. Each working group scheduled and conducted meetings during which members addressed issues in the group's area of expertise. At these meetings problems requiring solution were assigned to members for solution at their home organization. As a result of these efforts, a steady stream of improvements was made to the response process and equipment.

Early on, the community realized that frequent and realistic exercises were critical to developing and maintaining the new skills that a successful NEST response required. This resulted in a series of NEST exercises through the years. They include SUNDOG, EQUUS RED, MIGHTY DERRINGER, SX, JIGSAW III, NKLT, and MIRAGE GOLD.

In the summer of 1977, EG&G returned to Enewetak, this time to conduct radiation surveys as part of the clean-up operations and restoration of as many as possible of its 39 islands. EG&G has considerable successful experience in outfitting a variety of vehicles for field measurements. In this case, the vehicle of choice to navigate the coral sands of Micronesia was a snowcat. The snowcat was equipped with a 30-foot boom to carry detectors capable of surveying an area 50-foot in diameter. The crew spent 27 months on the islands.

Morning Light

In January 1978, Kosmos 954, a Soviet Radar Ocean Reconnaissance Satellite, (RORSAT), containing a nuclear reactor, broke up and fell to earth in the Canadian Northwest Territories, just 40 miles below the Arctic Circle. President Carter offered US technical assistance in locating the debris to the Canadian Government, which was quickly accepted.

Operation Morning Light was initiated, and planeloads of equipment and personnel were immediately dispatched to a staging point in Edmonton, Canada. The U. S. contingent was teamed with Canadian military personnel, who provided search transportation. More than 40 EG&G scientific and technical staff from Las Vegas, Washington, D.C., and Santa Barbara were part of the team. While parts of the satellite burnt up in the atmosphere, some radioactive debris did impact the earth's surface.

On site with radioactive debris in Canada

The effort of searching for a needle in a haystack was helped by a pair of Canadian trappers who just happened on a major debris site. Several large pieces were scattered over a large area with a 10-foot crater, which showed a high radiation level. Other fragments were found scattered along 140 miles of the satellite's reentry path. In all, the EG&G team conducted an aerial search over 30,000 square miles of Canada and identified the locations of the major radioactive debris.

Mount St. Helens

Pre-eruption photo of Mount St. Helens taken by EG&G in April of 1980.

In the spring and summer of 1980, EG&G AMO was tasked by the United States Geological Survey and the DOE to do a series of overflights of Mt. St. Helens in the middle Cascade Mountains of Washington State. In March, the mountain broke a 123-year dormancy with releases of steam and ash.

The objective of the survey was to obtain predawn and solar noon thermal imagery and aerial photography to locate potential hot spots. The last flyover occurred on May 16, two days before the first major eruption. The upper 1300-feet of the mountain was blown off the mountain. AMO returned in August to document the results of the eruption. EG&G's data contributed to the myriad of scientific experiments being conducted in proximity to the volcano. The scene of literally hundreds of studies, Mt. St. Helens is one of the best documented volcano eruptions in the world.

Back to NEST

In the fall of 1980, there was a new challenge for NEST. A bomb was placed in Harvey's Resort and Hotel near Lake Tahoe with a ransom note demanding $3 million in cash. The perpetrator, who claimed to have lost $750,000 at the casino, built the bomb with a half-ton of explosives and multiple triggers designed to detonate it if an attempt was made to defuse it.

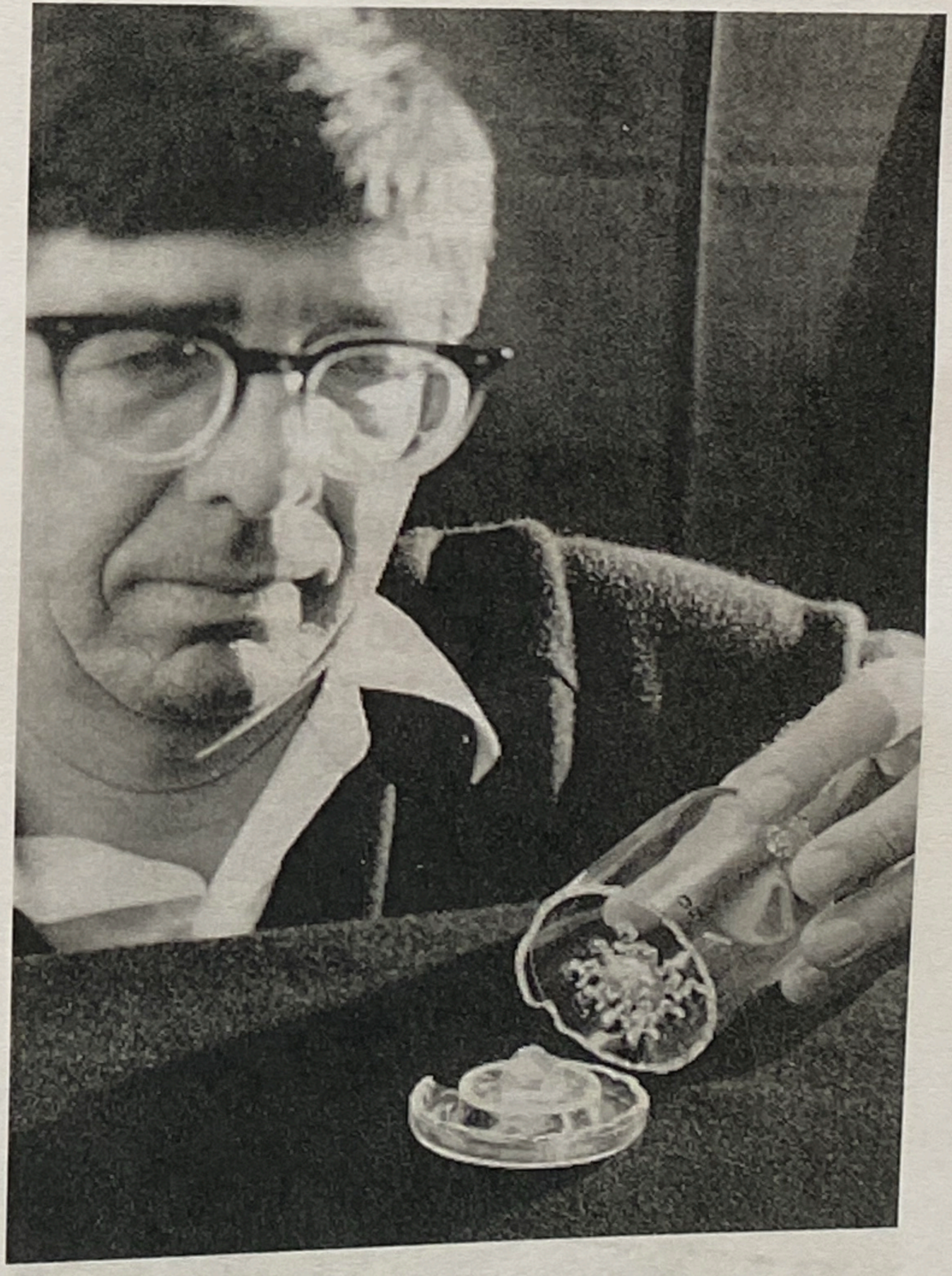
Responding to the situation was the FBI, the US military and NEST. After clearing the Casino and studying the device for hours, an attempt to explosively disable the trigger circuitry was tried, however the attempt set off one of the many booby-traps, detonating the bomb and destroying a large portion of the building.

The sophistication of the Harvey's Casino device, coupled with the inadequacy of the tools of that era to diagnose and disarm it was a watershed event for the team. While the device had only conventional explosives, it was clear that such complexities could exist in a makeshift nuclear device. To that end, the effort to improve operational techniques was redoubled.

Spacelab 3

. EG&G Santa Barbara Operations had been in quest for a superior room-temperature radiation detector since 1973. In that year, they began researching the potential of crystals grown from mercuric iodide as a room temperature radiation detector.

The launch of the Spacelab 3 shuttle mission from Kennedy Space Center, Florida, on April 29, 1985, gave EG&G the opportunity to have Lodewijk van den Berg on board to conduct a mercuric iodide crystal growth experiment in the microgravity environment of outer space. Lodewijk was the second payload specialist from private industry to fly in the shuttle.



Lodewijk van den Berg with crystal grown in space.

On a second flight, on January 22, 1992, the International Microgravity

Laboratory was flown by NASA. This was the company's second opportunity to experiment with mercuric iodide crystal growth in Spacelab's near weightless environment. The crystals found their way into a variety of detectors and instruments, but never became the commercial success that was hoped for at the start of the program.

More Remote Sensing

By the end of the 1980's, AMO had a fleet of 11 aircraft: six twin turbo BO-105 helicopters, three King Airs, a Convair 580T and Cessna Citation II jet. To support field operations, there was a mobile computer laboratory, a portable photographic lab and virtually tons of deployment equipment palletized and maintained for rapid deployment. The AMO staffing level at this time was about 260 people.

The airport expansion at McCarran Airport finally forced the relocation of AMO from the Escondido Facility to a new facility on Nellis Air Force Base. The Remote Sensing Laboratory (RSL) was established in December 1989. The first choice for a relocation site was the north side of McCarran, but problems in acquiring the land eliminated that option. In hindsight, the growth of Las Vegas and the expansions of McCarran over the years made the Nellis Air Force Base site clearly the better choice.

The Remote Sensing Laboratory at Nellis AFB.

Fifty years after the Trinity Test, AMS was able to map a very low-level Cesium 137 plume extending some 65 miles from ground zero. The plume was undetectable using ground measurements.

The AMS pioneered several navigation and guidance technologies to support the survey capability. These include the first transistorized Doppler Radar navigational system, a microwave ranging system modified to fly on an aircraft.

EG&G was also involved in a broad range of environmental monitoring besides that involving radiation. EG&G monitored, tracked, and cataloged endangered fauna and flora at the NTS and other DOE sites. One could come across a desert tortoise on the Test Site with a tiny radio pack glued to its shell, or a kit fox with a radio collar, under the scrutiny of an EG&G scientist.

A Kit Fox pup at Elk Hills Petroleum Reserve.

One of the other DOE sites involving environmental studies was the Elk Hills Petroleum Reserve near Bakersfield California. Among the hulking oil pipelines and rigs on the 49,000-acre desert site were endangered communities of San Joaquin Valley kit foxes, blunt nosed leopard lizards, giant kangaroo rats, and various plant species. EG&G scientists were responsible for conducting the ecological studies of the site, in response to the Endangered and Threatened Species Act of 1973

Acquisitions and New Contracts

Germeshausen announced the acquisition of Guillemin Networks Inc. as a new subsidiary at the 1964 annual Shareholders meeting. Guillemin Networks Inc. makes components for electrical networks. This first step was the forerunner of the initiation of a major acquisition program started in 1966 when Hydrospace Research Corporation and E. H. Plesset, Inc. were added as subsidiaries. Also, a wholly owned subsidiary, EG&G International, Inc. that encompassed oceanographic product and services activities, was formed. The acquisition program became the major growth vehicle for the future.

In 1967, 8 more acquisitions were added, including REECo. The REECo acquisition was made after 17 years of close association with EG&G at the NTS. REECo provided drilling, mining, and construction support to NTS operations. This added 5,000 new employees to the Corporation.

Another notable acquisition from 1967 was ORTEC, Inc. Formed by a group of scientists from Oak Ridge National Laboratory, they marketed a line of instrumentation for use by research scientists in the field of low energy physics that became the industry standard. Between 1968 and 1971, six additional acquisitions were made. One of the acquisitions of this group was Sealol Inc., a manufacturer of sealing devices since 1958.

In 1969, the company had its earnings fall into the negative column for the first time in their history. With the realization that they lacked senior management with experience in commercial product operations, they recruited and hired Dean Freed in 1970, who joined the company as a Senior Vice President. Dean Freed was elected President of EG&G Inc. in 1977.

In 1972, EG&G made four new acquisitions, including Challenger Research, Inc., a company co-founded by John Kucharski. Challenger Research was merged with a previous acquisition, Hydrospace, as the first step towards the formation of EG&G Washington Analytical Services Center, Inc. (WASC). Also, this year, Germeshausen retired from full time employment and O'Keefe was elected CEO. In 1975, Wolf Research and Development, a 1967 acquisition, merged with Hydrospace-Challenger to complete the formation of WASC. Kucharski continued to manage WASC until 1981, when he was named vice president of the Custom Services and Systems Group. A few years later, the DOE contract work was also brought under his responsibility.

In 1976, EG&G made its first venture into DOE business outside the weapons test work and was awarded the contract to operate the Idaho National Laboratory by ERDA.

In the same year, Grier retired as an employee and continued as Director. Herbert Grier was the last founder with an operational role. He continued his association with CER on an informal basis.

At the Kennedy Space Center, NASA's Shuttle program had evolved into an operational mode, awarding three major contracts. EG&G Florida was selected as the Base Operations contractor and undertook its responsibilities on January 1, 1983. The EG&G workforce of approximately 2,000 fulfilled the responsibilities that were previously carried out by thirteen separate contractors. Their activities ranged from the design of rocket fuel delivery systems, procurement, facilities and grounds maintenance, security, training, and life support.

Dean Freed was elected Chairman of the Board of EG&G Inc. after the 1985 annual meeting, replacing Barney O'Keefe. O'Keefe quipped at the Annual Meeting that he instigated mandatory retirement for the position of Chairman at age 65, never thinking it would affect him. John Kucharski was named Executive Vice President, responsible for the overall operations of the corporation at the same meeting. One year later, John Kucharski was named President. In 1987, Kucharski was elected Chief Executive Officer and 1988, Chairman of the Board.

In 1988, EG&G was awarded a 5-year, $1 billion contract with the DOE to manage the Mound plant in Miamisburg, Ohio, and established a new wholly owned subsidiary, EG&G Mound Applied Technologies Inc. The defense work that began in 1943, based on the production of radioisotopes, was expanded to tritium and other weapons components including detonators, timers, transducers, firing sets, pellets, and actuators. Mound also produced isotopic powered thermoelectric generators and atomic batteries used in the space program and in other applications.

In 1989, EG&G was asked by the Department of Energy (DOE), to undertake the management and operation of DOE's Rocky Flats Plant near Denver, Colorado. Adding this contract to the other four major DOE contracts raised EG&G to the fourth largest DOE contractor. EG&G had 10 percent of the DOE market, behind Westinghouse, University of California Systems, and Martin Marietta. Also in this year, the Department of Army awarded EG&G the prime contract for chemical weapons disposal at Tooele, Utah.

The Superconducting Super Collider

In 1988, EG&G, teamed with University Research Association (a consortium of over 90 universities engaged in high energy physics research) proposed on, and won a DOE contract to design, construct, and operate the Superconducting Super Collider (SSC) to be constructed near Waxahachie, Texas.

The SSC was the grandest high energy physics machine ever conceived and funded up to that point in time. It would have featured two 20 TeV (trillion electron volts) counter rotating proton beams which were to be housed in a 54-mile-long oval tunnel, 14 feet in diameter. The tunnel would be situated 30 to 100 feet below the surface in an Austin Chalk underground formation in Ellis County, Texas.

The SSC was conceived to validate the Standard Model of particle physics by recreating the conditions believed to exist at the beginning of the formation of the universe, and in particular, find the Higgs-boson, a hypothetical massive elementary particle of matter predicted to exist by the Standard Model and is the only Standard Model particle not yet observed, but plays a key role in explaining the origin of mass of other elementary particles.

The collider would have consisted of four progressively higher energy accelerators, one feeding into the next at ever increasing energies up to 20 TeV for each of the counter rotating beams of the final stage giving a total of 40 TeV in the center of mass system. The particles (protons) were to be kept in very tight beams by over 10,000 superconducting magnets as they raced around the loop multiple times at velocities close to the speed of light. The beam, as it was called, was about the diameter of a human hair and had to be held to within a one-inch target area throughout the machine. Collisions, at an energy of 40 TeV, were to take place in specially designed detectors, one of which weighed over 45,000 tons (about the size of a battleship).

EG&G formed a wholly owned subsidiary, EG&G Science Support Corporation, to manage their portion of the project and named Jack Story as President and General Manager. Story was also an Associate Director for the SSC Laboratory and Director of the Technical Services Division for the SSC, basically responsible for developing much of the infrastructure and operational support for the project. Although this project was not in the DOE Weapons Test arena, many of the key senior people on the project came from that background.

One of the first hurdles the project faced was to prepare an Environmental Impact

Statement (EIS), a document required by the National Environmental Policy Act (NEPA) before the project could officially begin. Jack Story called upon EG&G's Washington Analytical Services Center (WASC) and, specifically, Phil Shelley to assist them in that endeavor. Shelley also prepared the first DOE Mitigation Action Plan, a document that would be used to monitor the SSC's efforts to minimize adverse environmental impacts. Shelley eventually transferred from WASC to SSC and took Story's place as President and General Manager when Story retired in 1994.

At the end of 5 years, SSC had 750 employees and annual sales of $120 million. In 1993, after completing the first 3 accelerators and over 30 miles of tunnel, the project lost its funding and was cancelled. URA had planned to be operating the SSC before the year 2000. As part of the closure, the tunnel was closed, and the open shafts and tunnel were backfilled for safety reasons. (Note that CERN had the largest particle accelerator in the world at that time, the Large Hadron Collider (LHC), in operation in 2008, was designed to have an energy level of about 15 TeV.)

The Final Chapter

In 1995, and after the loss of the INEL recompete, EG&G made the decision not to re-compete their remaining DOE contracts at Nevada, Mound, and Rocky Flats. These contracts expired on various dates though September 1996, forever changing the nature of the company. The focus for the future was to be the commercial business.

In 1997, the company began a search for a new president. Gregory Summe, formerly president of AlliedSignal Automotive Products, was hired and appointed President and COO in February 1998. In January 1999, Summe was named CEO, replacing Kucharski, and Chairman of the Board at the annual meeting in April 1999.

Earlier, EG&G began looking for a buyer for the remaining government businesses after their most recent acquisition, the Instrument Division of PerkinElmer, Inc. The deal included acquiring the name PerkinElmer, so when a buyer was found for the government businesses, the company also sold the EG&G name and EG&G, Inc. became PerkinElmer, Inc. in September 1999. The company that acquired the government businesses, The Carlisle Group, set up the government businesses as a privately held company called EG&G Technical Services, Inc.

EG&G Technical Services, Inc., was again sold in July 2002, this time to URS Corporation, a large engineering and design firm headquartered in San Francisco. URS is publicly traded on the New York Stock Exchange.

Under URS ownership, EG&G retained its unique identity as well as its name. Was then called the EG&G Division of URS, EG&G remained a major Government services contractor, holding contracts with the Department of Defense (DOD), Department of Energy (DOE), Department of State (DOS), Department of Transportation (DOT), Internal Revenue Service (IRS), and National Aeronautics and Space Administration (NASA).

It is possible that sometime in the future the EG&G name could be eliminated by URS because of a single brand strategy, if so, that would indeed represent the final chapter in the history of our country's premier company brand name – a history that is inextricably linked to the Cold War and the amazing saga of the development and proliferation of atomic and nuclear weapons. The loss of the name would be sad, but would certainly not mean the end of EG&G. As long as there are those of us that remember, EG&G will be with us, and its existing employees will carry the culture under a different banner.